POWER PLANT ENGINEERING

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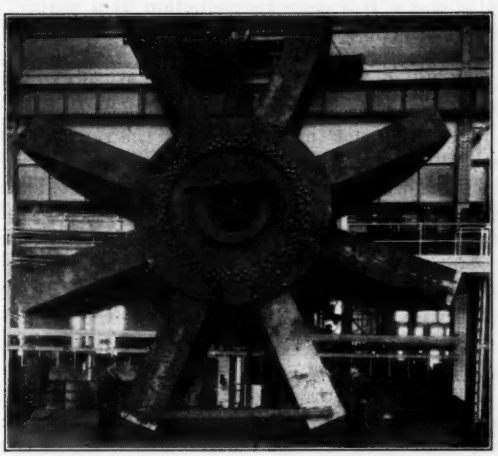


The Rushin Situation

INTEGRATING REPORTS put out by 2-day to 2-months tourists, we find that Russia is responsible for fully 90 per cent of the ills of the world, including the unusual weather exported by it to Southern California.

We must admit, however, that the Russians do raise men—real MEN—like Comrades Watt-A-Manoviski (left) and Watt-A-Mannovitz (right) who are shown above nonchalantly juggling a 90-t. Roosian Spider. And that's not all. After the picture was taken they calmly folded it up and carried it off in a suitcase! In a few weeks, Hugh Cooper will use it as a bearing bracket in the Dneiper River plant.

Hugh is quite a boy himself. It seems that after the Young plan for old Europe was finished, with a business eye for the interest of the stockholders, all carbon copies and prints of ramifications and interrelations were turned over to the General Electric Research Department. These were put into a mammoth kaleidoscope and the result turned out to be an eight-tentacled octopus which the engineering department trimmed up a trifle and, because of its eight legs, called it a spider.

About that time Mr. Cooper came along and seeing its possibilities, caught the first boat for Russia. Of course, the world laughed when he sat down and began to play Bigger and Better Hydro-plants on the glass top of the conference table. But now they sit around with wide eyed astonishment and admiration.

Hydraulic engineers are like that, though. The same hoarse laugh sounded when some engineers planned something a little different in Michigan. These adventurers found a nice likely looking river and with some sheet piling, a lot of mud, some turbines and an oversize rat hole under the mud pile made Hardy Dam, described on page 194. Now the skeptics admit that the laugh was a little premature because the Consumers Power Co. is turning out bigger and better kilowatts than ever seen before in that part of the country.

WITH THE EDITORS

Pseudo Art and Engineering

In a recent issue of the monthly bulletin of the National Electric Light Association there appears on the frontispiece a full page reproduction of a painting entitled "Electric Power," a modernistic impression of Diego Rivera, well known Mexican artist. This painting was exhibited at the Museum of Modern Art in New York this winter.

Whether or not the N.E.L.A. by the reproduction of this painting in its bulletin gives its approval to this type of art we do not know since it is presented without comment but we sincerely trust that it does not; for this picture is as crude and uncouth an example of so-called modernistic art as has yet come to our attention. If this is an artist's conception of electric power, symbolic or otherwise, it is indeed fortunate for the human race that it is not dependent upon the artistic profession for heat, light and power.

Now, it is not our wish that any human being, artist or otherwise, should be limited in the free and unhampered expression of his ideas—indeed, if, as Branch Cabel contends, the sole object of the artist is to divert himself, it is nobody's concern as to how he expresses himself; but it is, indeed, a sad spectacle to find other supposedly sane human beings regarding as works of art, atrocities which would disgrace a six-year-old child armed with a paint brush and a canvas.

A few years ago, there was exhibited in the galleries of the Art Institute of Chicago another painting which depicted the "lineman." This hideous object, a stoop-shouldered, degenerate type, seemingly in the last stages of some dehumanizing disease, was supposed to represent the lineman, the man who risks his life through storm and hardship in order that electricity may be carried to our homes and industries. We in the engineering profession, who know the character and fine physique of the linemen who maintain our transmission lines, know, of course, that such a picture is nothing more than a discredit to the artistic profession which endorses it and we trust that the average public is intelligent enough to share our viewpoint; but the mere fact that such pictures, if such they can be called, are given place in our finest art galleries is lamentable.

We do not claim to be artists, nor do we desire to impose restrictions upon those who call themselves artists; but it seems to us that when such conceptions as this one of Rivera's is exhibited to the public, we should be quite as daring and fearless in criticizing them as are the artists in presenting them. Rivera may be a great artist and he may have produced really fine paintings but this, certainly, is not one of them. We cannot believe that any person having a truly artistic temperament can be sincere in presenting such conceptions to the public as works of art. Much of this so-called modernistic movement is little more than a racket on the part of an ever-growing group of pseudo artists.

In thus criticizing, it must not be inferred that we are opposed to modernism. On the contrary, we are quite enthusiastic about all modernistic movements provided they are in good taste and that they do not offend our inherent sense of beauty but when such grotesque, exaggerated representations of things with which we are familiar are presented to us as being a modernistic impression of our industry, we feel no hesitancy about expressing our candid opinion of them.

Hoarding

Accumulating a reserve against future contingencies is a most praiseworthy and essential aim if one is to achieve financial security. Every thoughtful person has had that end in view. Only one method is possible—keeping expenditure less than income and adding the difference to the gradually accumulating reserve so that it shall be safe and available when needed; yet it should be put to work as capital to bring returns.

During the past few years we have had painful lessons as to the danger of trying to secure too large returns, and even following the advice of supposedly conservative and reliable investment bankers and trusting the soundness of banks has often been no assurance of safety. It is not surprising, therefore, that hoarding currency has become almost epidemic, the amount so held inactive being estimated by the Secretary of the Treasury as $1,500,000,000. On the basis that each dollar in use serves as a basis for $10 of credit, this reduces the credit available for doing business by $15,000,000,000, which is an important factor in slowing down business recovery.

Spite of unfortunate experiences, sound investments and sound banks are and have been available. For greatest security, U. S. Government bonds and Postal Savings are as reliable as is the existence of the country. With the functioning of the Reconstruction Finance Corporation, which is intended to stabilize and assist solvent banks and businesses, there seems to be good reason to expect that well-managed undertakings can make satisfactory progress and use funds profitably.

To buy an automobile so as to have a means of going somewhere, then put it in storage because some automobiles are stolen and have accidents is akin to saving money when hoarding it in safety deposit or the stocking bank. Both should be put to work if returns are to be had. Keeping either one out of circulation makes it of little value to the owner or the community. Either one, put to use with due consideration for safety, can contribute to the welfare of the owner and the community.

Better supervision of banks is needed but that has been learned and at no time have the strongest ones been in danger.

Change in the attitude of investment bankers as to their responsibility to investors is essential, if they are to regain the confidence of the investing public. Some of them probably realize this; others will come to as time goes on. But the soundest and strongest of our utilities and industries, whose managements have kept them free from stock promotion and market manipulation, have at all times been in good condition and their securities are available to the careful investor.

Hoarded money, like reserve power equipment, is a safeguard against emergencies but only as it is put to work can it become profitable.

Suggestions for Profitable Reading

Earth Dam and Automatic Controls Are Features at Hardy Dam

Have you always believed that dams and hydro-electric plants must be built on solid rock foundations? If so, you will doubtless be surprised and interested, in reading the leading article in this issue, to learn how the engineers of Consumers Power Co. in Michigan have built an earth dam 120 ft. high and 3000 ft. long on a foundation of sand and mudstone. It is believed that no other earth embankment of this height, also containing through penstocks and power house in the deep section, has been built on earth foundations. For this reason, also because the settlement of the structure has occurred almost exactly as provided for in the design, considerable detailed information about the design and construction of this project is given in the article.

Another important feature of the Hardy project is the extensive use of automatic controls, not only for starting and stopping the generating units merely by throwing a switch to "start" or "stop" positions, but also for operating head gate hoists, spillway valves, penstock filler valves and all auxiliary motors can be controlled from switchboards in the power house with lockout controls at the motors to safeguard the operators. Besides these features, relays of various kinds protect the generating units against high temperatures and other operating contingencies. Since the Hardy plant is primarily a peak load plant, as discussed in detail in the article, the ability to put units on the line rapidly constitutes a great advantage.

For More Power in Limited Space, Consider This Application of the Benson Boiler

Marine application of super high pressures is being investigated and results seem to indicate that superimposing super-pressure turbines on an installation of the usual type will give added power at low first cost and operating cost in a minimum of space. The method, as tried in a marine plant, described in this issue by Dr. Goos seems applicable to stationary plants which need more power.

What Does It Cost You to Handle a Ton of Coal or Make a Ton of Ice?

Coal unloading costs are often difficult to segregate, consequently you will be interested in studying the coal handling costs for a small plant as determined from past records. You may find here some methods of getting at these costs that you can use in your own plant. In the plant mentioned, unloading of 150 cars annually by a portable conveyor costs about $1.63 for fixed charges and $1.38 for operating costs per car, a total cost of about $0.055 per ton.

Of course, no operator can know how good his plant is until he has some standard of comparison. Mr. Lincoln, in this issue, says that, unless you can make a ton of ice for from 40 to 45 kw-hr. per ton, your plant will stand a close and intensive investigation to determine why you cannot. All plants do not attain this figure but the good ones do. Since you are a wide-awake operator, you already have the necessary data to find out where you come on his scale of performance. It's just a question of knowing how to analyze your data. If you haven't the information, it is well to get it before somebody who knows how comes in and causes you some unnecessary embarrassment.

Keep Equipment and Plant Clean and Eliminate Many of Your Troubles

Leaky condensers, for example, contaminate the feedwater, increase the turbine water rate and raise the auxiliary power consumption. Proper installation of condenser tubes to prevent these troubles is not hard if you have the proper tools and equipment, otherwise it is a tedious job that is not likely to be well done. The modern way is to roll or expand at least one end of the tube. Sometimes one end is packed, with or without ferrules. Proper use of the necessary tools for this important task is discussed in the article, Improving Plant Performance by Condenser Maintenance.

Cyclones to take another example, are more important than brooms in keeping our industrial plants clean but unfortunately information about them is not so widely disseminated as it should be. Mr. Whiton speaks with authority on this subject and shows by test data and curves the effect of size, air temperature, particle size, air velocity and dust loading on efficiency.

Technical Developments in the Central Station Continue Steadily and Surely

Harding St. Station is one of the first to use the new Deion circuit breakers. Besides this, it has a most interesting voltage chaser scheme. If for any reason a main generating unit should fail, its respective house unit would also be affected but the essential auxiliaries for this main unit, such as circulating pumps and condensate pump, will be kept operating by the voltage chaser equipment so that the main unit can be restored to service as quickly as possible. Besides containing a detailed description of this operation, the article in this issue describes the electrical system from the main generators, through to outdoor switchyard and auxiliary, the control room and auxiliary power supply system. Mechanical features of the station were described in the Feb. 15 issue.

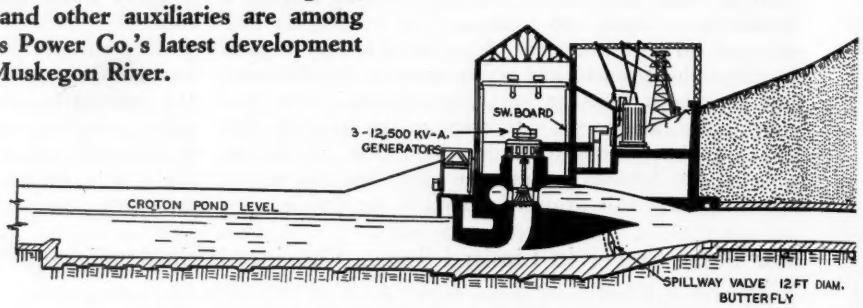
Among the optimistic notes of the year is the load increase of the Northern States Power Co., which necessitated the addition of a 35,000-kw. unit to its Riverside Station in Minneapolis. Steam conditions in the station were increased from 230 lb., 600 deg. F. to 400 lb., 750 deg. F. as discussed in this issue. Extracted steam from the new unit increases the final feedwater temperature of a portion of the old station from 210 to 287 deg. F.

POWER PLANT ENGINEERING March 1 1932

Hardy Dam Provides 40,000

Earth dam 120 ft. high on sand and mudstone foundations with buried penstocks and concrete overflow weir; complete automatic control of three 13,300-hp. water-wheel generators; remote and automatic control of head gates, butterfly spillway valves and other auxiliaries are among features of the Consumers Power Co.'s latest development on the Muskegon River.

By
EDWARD M. BURD
Civil and Hydraulic Engineer
Consumers Power Co.



WHEN THE Croton and Rogers Hydroelectric Projects of the Consumers Power Co. were built in 1906-7, on the Muskegon River in the western part of Michigan, an undeveloped fall of 100 ft. was left between them. Except for surveys and studies of possible development sites, this fall was held unused until 1926, when further investigation was made, to form the basis of another hydroelectric development at this point. Since this district provides only glacial drift for foundations instead of rock, considerable care had to be taken to find the best possible foundation conditions. After considerable prospecting, however, a suitable site was found near Newaygo where a 20-ft. thickness of this mudstone (consolidated rock flow from glacial outwash) could be used for power house and intake tower foundations. The Hardy development described here was then designed for this site and was put into operation about May 1, 1931.

Principal parts of this Hardy development are the earth dam, with concrete corewall and concrete overflow weir, the penstocks running through the base of the dam, the intake tower, the power house on the downstream side of the dam, with bypasses leading from the penstocks under the power house to the draft tubes to provide spillway capacity. The power house, which is outside the embankment, contains three 12,500-kv.a. vertical water generating units, giving a total capacity of 37,500-kv.a. at 7200 v., stepped up to 140,000 v. for delivery to the system over a 48-mi. transmission line to Grand Rapids. Automatic controls for generating units and water control equipment are used as extensively as possible at Hardy.

Conditions Governing Operation at Hardy

Operation of the Hardy project will come under three classifications: normal, emergency and special. Under normal operation the plant will supply the system load requirements, improving system efficiency by permitting older and more inefficient steam plants to be held in reserve for emergency operation. Hardy will normally operate as a peak load plant, generating only during times of high system demand, to improve loading of the steam plants on the basis of both daily and weekly load factor. Besides this, Hardy is operated at all times during normal conditions to obtain maximum

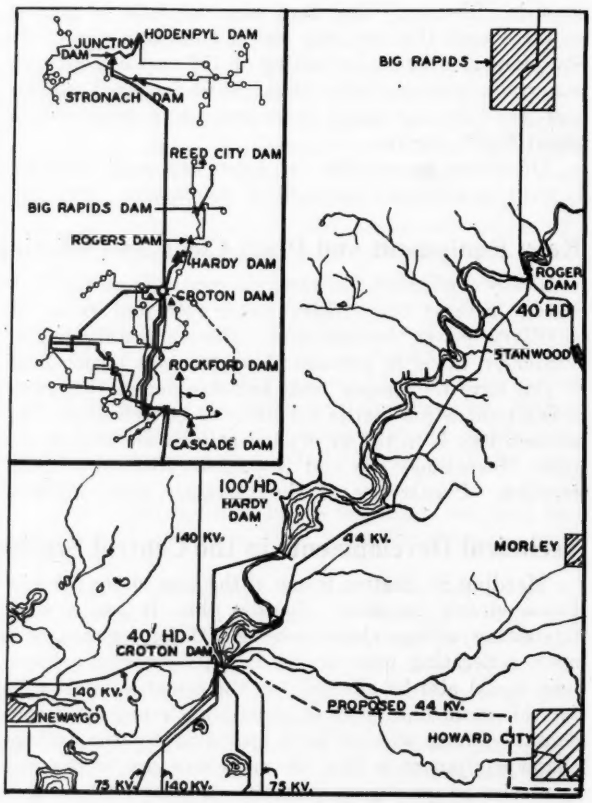


FIG. 2. LOCATION OF HARDY DAM. INSERT SHOWS HOW IT IS CONNECTED INTO TRANSMISSION SYSTEM OF CONSUMERS POWER CO.

Hp. for Michigan Peak Loads

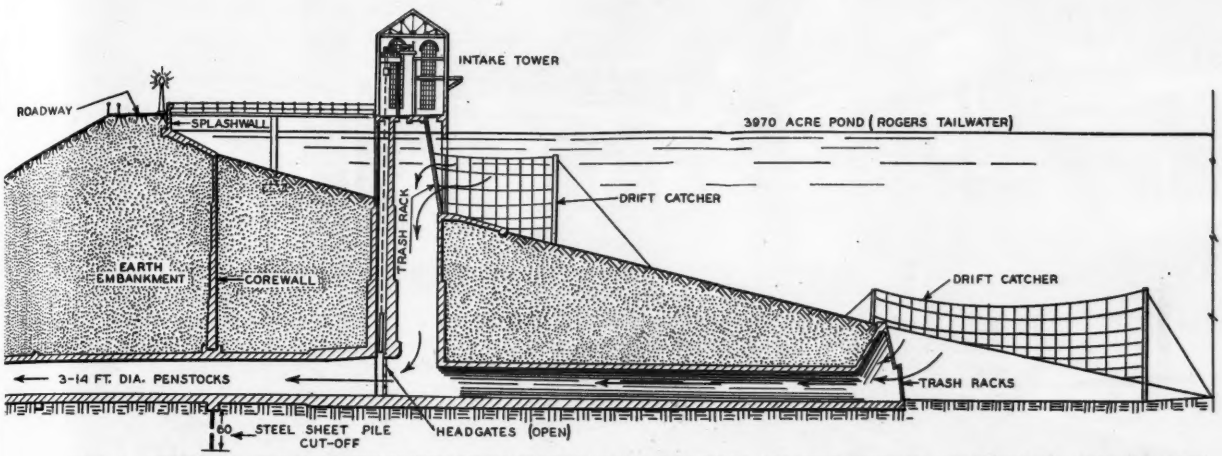


FIG. 1. GENERAL CROSS SECTION THROUGH HARDY DAM, SHOWING INTAKE WORKS, PENSTOCKS, POWER HOUSE AND GENERAL CONSTRUCTION OF DAM

plant efficiency, the three units operating in combinations such that each operates at its most efficient load. Finally, because of its automatic features and because its 40,000-hp. capacity is ready to go into service at extremely short notice (when compared with the time required in steam plants to put generating units on the line) the Hardy plant is particularly valuable in emergency operation during storms and abnormal system conditions. If an emergency of long duration occurs, the water storage capacity of Hardy can be used; a draw-down of the pond for this purpose has the further advantage of increasing the output at Croton and Newaygo plants downstream from Hardy.

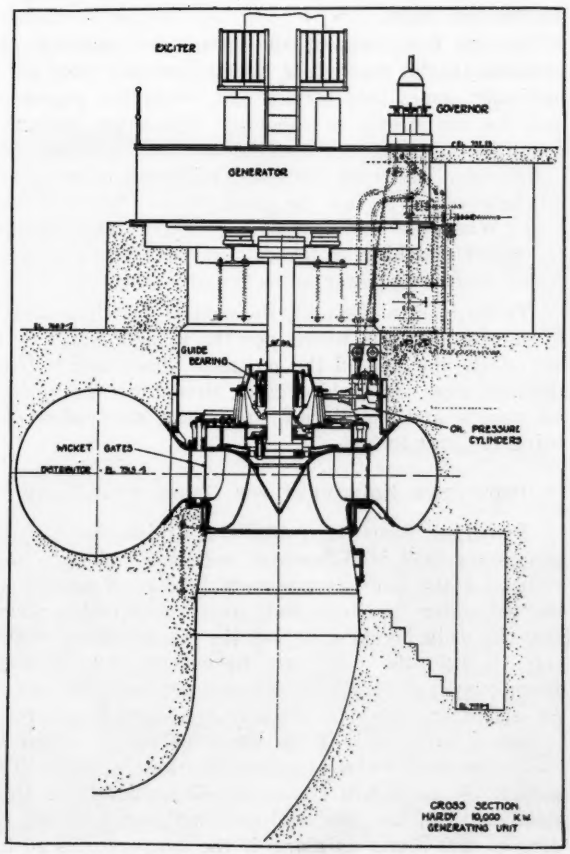


FIG. 3. DETAILS OF ONE OF THREE 13,300-HP. GENERATING UNITS

Under the third or special type of operation, the amount of pond draw-down will be varied in the winter to control the heavy river runoff that occurs when the snow melts and the spring rains set in. This draw-down will occur during low river flow, when there is shortage of hydraulic capacity and pond filling will be carried on when river flow is high and there is excess hydraulic capacity. This method will tend to eliminate spilled water during high flow and to smooth out fluctuations in the flow of the Muskegon River. An additional advantage is that during late summer when river flow is light, additional generation at Hardy will be possible if it is needed, with resulting draw-down, followed by curtailment of output to fill the pond again during the fall rains.

Automatic Control of Generating Units

In the Hardy power house itself, the principal items of interest are the automatic features and electrical controls, which illustrate modern tendencies in hydroelectric design. The generating units consist of three 13,300-hp., I. P. Morris, Francis type, vertical hydraulic turbines, designed for 100 ft. head and 163.6 r.p.m. set as shown in Figs. 1 and 3, each driving a General Electric 12,500-kv.a., 7500-v., 0.8 power factor, 60-cycle, 3-phase vertical generator. These units are equipped with Woodward governors. Main thrust bearings are on the top side of the generators, with guide bearings for the shafts just above the hydraulic turbines. Each thrust bearing thus carries the entire weight of its generator rotor and water wheel plus the hydraulic thrust of the water as it passes through the wheel, a total pressure

FIG. 4. IN THE ATTRACTIVE HARDY POWER HOUSE ONLY THE THRUST BEARINGS AND EXCITERS ARE ABOVE THE FLOOR

of about 290,000 lb. Above the thrust bearing are mounted the main and pilot exciters and these with the thrust bearing itself are the only parts of the unit above the operating floor, as shown in Fig. 4. Generators, below the floor, are completely enclosed; they are cooled by standard generator air coolers like those used with steam-turbine generators.

Installed just outside the power house, Fig. 1, a bank of three Allis-Chalmers main power transformers, 12,500 kv.a. capacity each, steps up the voltage from 7200 to 140,000 v. for connection to the transmission line.

These generating units can be started or stopped entirely by the automatic controls following the pushing of a button by the operator to give the initial impulse. When the control switch for a unit is moved to "start", it energizes a master relay, which closes the generator field switch, starts the motor-driven turbine guide bearing oil pump and energizes the starting solenoid on the governor. The governor mechanism is designed so that when this solenoid picks up, the turbine wicket gates begin to open slowly under limiting control of a mechanical turning device. A servomotor actuated by oil pressure furnishes the power for this gate-opening operation. As the generator speed gradually increases up to approximately synchronous speed, the mechanical limiting device relinquishes control of the governing mechanism, this control having been assumed by the governor fly balls, the driving motor of which now receives its power from the auxiliary exciter. When the machine has reached 95 per cent of synchronous speed, an automatic centrifugal switch on the generator shaft cuts in an automatic voltage regulator, also the two speed-matching motors, which adjust the speed of the unit to the frequency of the power system, while the voltage regulator adjusts the voltage to a predetermined value.

As the frequency of the incoming generator approaches that of the system, a synchronizing relay automatically comes into service and, when the generator and line are exactly synchronized, this relay closes the generator circuit breaker. This operation cuts out one of the speed-matching motors, leaving the other to act on the governor so that the generator will begin to take load. When the load reaches a predetermined amount, the speed matching motor cuts out and the generator is now delivering power to the system.

To shut down the unit, the control switch is moved to the stop position, whereupon the various relays operate to take the load off the generator, disconnect it from the line, close the turbine gates, shut down the various oil pumps and auxiliaries, apply the air brakes and bring the unit to rest.

Protective Equipment for Generating Units

Principal items of protective equipment for the generators include differential relays to take the machines off the line automatically in case of trouble in the generator windings and overcurrent relays which trip the main breakers during the synchronizing operation in case the units are incorrectly synchronized. Rotor temperature recorder on each generator will sound an alarm in case the temperature exceeds a predetermined value and, if the condition is not remedied, the recorder operates to reduce the load automatically so that the rotor will run at a safe temperature. Generator stators are also equipped with temperature recorders that sound an alarm if the temperatures go too high at various points around the machine and that

record also the temperature of air in the generator cooling system.

Water Control Equipment

Water reaches each of the three water wheels through separate 14-ft. diameter steel penstocks, controlled at the intake tower. Each penstock has a spillway valve, consisting of a 12-ft. butterfly valve, in the power house, to bypass water under the turbines if it cannot all be used for power. These spillway valves and the head gates at the intake tower, Fig. 1, are operated from the power house switchboard. When a starting button on this board is pushed, the spillway gates open or close, the movement continuing automatically until the gate is fully opened or closed, its position being indicated by a system of signal lights on the switchboard. These butterfly valves can be held in any partially opened position by their self-locking double-worm drives. In a similar way, pushing a starting button on the switchboard will start the head gate hoist, the operation continuing until automatically stopped when the gate is fully opened or closed. To ease the normal operating loads on the penstock gate hoists and cables, an 18-in., switchboard-operated filler valve on each penstock can be used to fill the penstock with water before the head gates are open, although all parts are designed for operation against full unbalanced head. Light signals show the operator the positions of filler valves and head gates, while pressure gages in the power house inform the operator of penstock pressure.

Many of the motors throughout the plant can be started or stopped from the switchboard. These motors are also provided with duplicate control near the motors, including lock-out buttons to prevent operation from the switchboard, thus safeguarding men working on the motors.

As noted above, one of the principal features of interest in the Hardy development is the earth dam built on a glacial drift foundation. The dam contains about 1,400,000 cu. yd. of earth; it is 3000 ft. long on the crest and 800 ft. through at the base. A concrete corewall runs through the dam longitudinally, with a steel sheet piling cut-off wall extending 60 ft. below it. This cut-off wall has effectively stopped underground seepage, which is a major problem on glacial foundation. Power house and intake are separated, as shown, by the buried penstocks, to decrease and spread out the loading and this also simplified design and construction.

Details of Construction of Dam

First the 14-ft. penstocks were built on the best mudstone available at a depth to allow the river to flow through them when the natural channel was blocked. These penstocks have flexible joints at 30-ft. spacing, both in the riveted steel liners and in the reënforced concrete encasing shells that transmit the embankment load to the penstock foundation. Joints between intake and penstocks and between penstocks and power house were designed to permit a possible movement of several times the settlement expected for the whole structure. Except for these points, the intake tower was designed as one unit and the power house block as another unit.

After the penstocks were practically finished in the spring of 1930, the embankment was begun. The sheet pile cut-off was put in, beginning at each end of the embankment, then corewall construction began and then earth fill, the cutoff wall and corewall being carried ahead of the fills. This procedure gradually narrowed

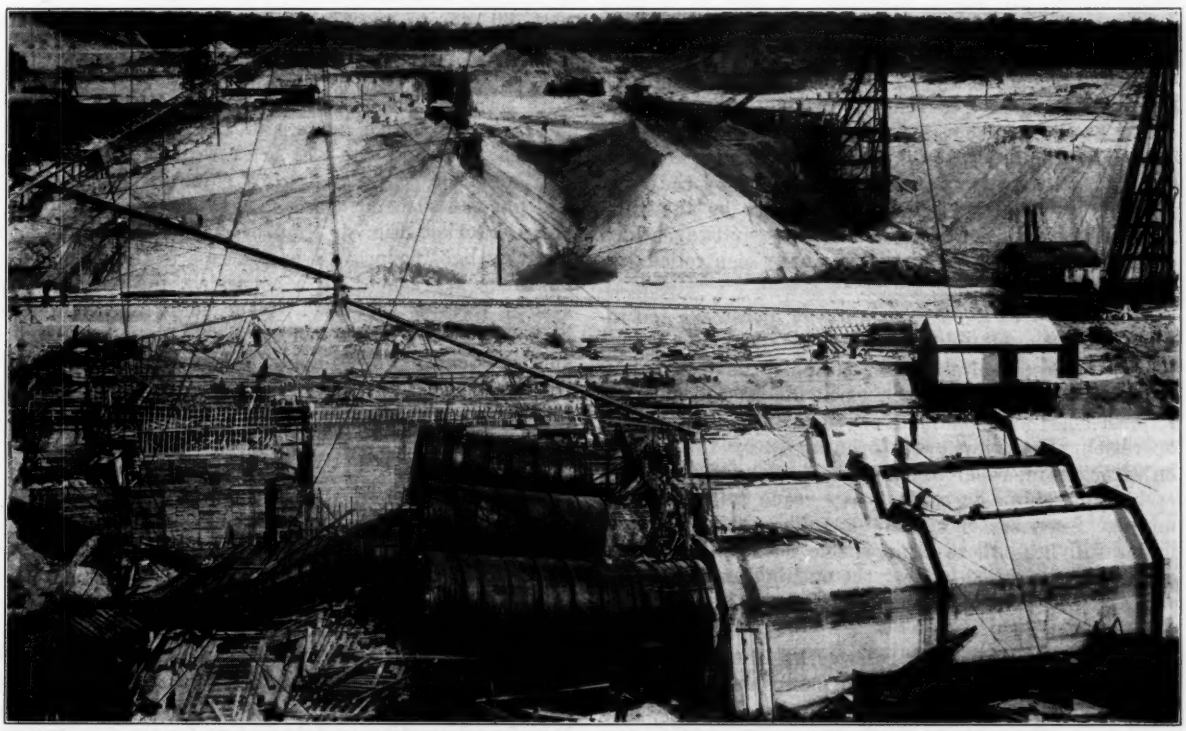


FIG. 5. EARLY STAGES OF CONSTRUCTION AT HARDY. POWER HOUSE END OF PENSTOCKS IN FOREGROUND, COREWALL AND EARTH FILL IN BACKGROUND

the river channel, making closure possible during mid-summer low flow by causing the river to flow through the low level intake and the penstocks. Meanwhile intake tower and power house foundations had been started upward. The dam was then filled in by dumping and sluicing earth into place. Figure 5 shows the penstocks under construction at the power house end; in the background the corewall pushes out from the north shore, followed by the earth fill.

Emergency Spillway of Unusual Design

Spillway capacity somewhat greater than at Croton and Rogers is provided at Hardy by the three 12-ft. butterfly valves controlling bypasses from penstocks to draft tubes. Additional emergency capacity of double the service spillway capacity is provided by a concrete

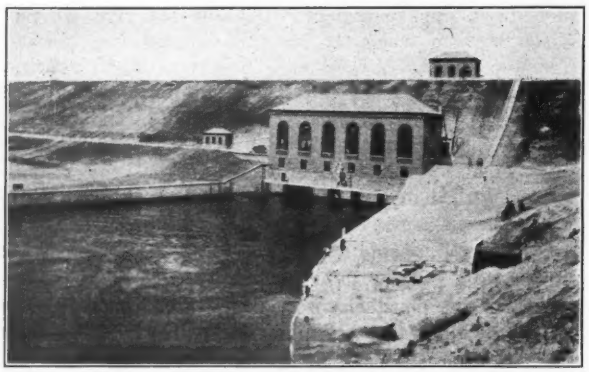


FIG. 6. EXTERIOR VIEW OF HARDY POWER HOUSE AND PART OF DAM

overflow weir and paved channel at the west end of the embankment, an added safeguard in case of a flood greater than ever experienced in Michigan. This overflow weir is built of short concrete sections of varying thickness and stability, designed to overturn and wash away progressively, so that spillway overflow will increase as the pond level rises but will never exceed or even equal the inflow to the pond. In this way, any sudden and extraordinary inflow is cushioned by the great area of the pond itself and still further by the automatic choking action of this emergency spillway, which is free of all gates or other manually controlled elements.

For control of the service spillway, penstocks and intake gates, no attendance is necessary at the intake tower. As described above, all equipment is operated by push button from the switchboard. Each head gate has its own hoist with complete switchboard indication and operation. Each gate, with opening 12 by 19 ft., runs on seven 28 in. roller bearing double flanged wheels on each side, rolling on extra heavy crane rail at 2 ft. a minute. Seals are of adjustable rubber bulb strip and under full head there is no visible leakage. The gates ordinarily are raised to clear the opening and are closed when a unit is shut down over night to save turbine gate leakage.

Since tail-water stands halfway up in the penstocks, a quick unwatering 12-in. sump pump and crane-operated steel tail gates are provided for each unit. These can unwater a penstock and draft tube in less than two hours. A bypass permits unwatering the penstock ahead of the spillway butterfly valve, if desired. On these valves, steel edges engage babbitt seats in the housing and effectively prevent leakage.

Settlement of the various structures of this development was expected to be about 4 in. under center of embankment. Actual settlement record was kept throughout construction and to date on 20 points on the corewall, 25 points on the embankment and 20 points on penstick and power house structures. Corewall points were carried up from its base to make certain that true settlement at the base of the dam was obtained. The data show that the corewall base has settled 3½ in. through the highest part of the dam, with a maximum of 4 in. and that settlement has decreased in proportion to the load toward the ends of the dam. Settlement of embankment fill itself has been about 1½ in. Penstocks have settled about 3 in. under the corewall, decreasing gradually to about 1 in. at the power house, which has also settled only 1 in. because of the reduced loading resulting from its location outside the embankment. These relatively small and uniform settlings practically ceased at the time the embankment was topped out in the fall of 1930. Additional load caused by filling the pond in the spring of 1931 increased the settlement only a fraction of an inch; this was less than was expected. There has been no further movement in 10 mo. since the pond was filled.

Architectural Treatment

All the above results were anticipated and provided for in the design. So far as is known, no other embankment of this height, containing also through penstocks and power house in the deep section, has been built on earth foundation. This design and construction continues an engineering policy pioneered by the Consumers Power Co. and developed by its engineers during the past 30 yr. to meet the requirements of Michigan geology.

Architectural features of the Hardy development have received considerable attention. Exteriors of the power house, intake house and other buildings are in two-tone buff and tan face brick with green tile roofs. Red tile floor, salt-glazed brick sidewalls in two tones and paneled suspended ceiling give an attractive power house interior, Fig. 4. Improved highways and good highway lighting provide easy access to the plant. The buildings are heated by a concealed, indirect, hot air system from a coke-fired steam boiler in the power house, because the plant will probably shut down nights and week-ends. Power house and intake tower are attractively floodlighted, the surroundings are carefully landscaped and attractive houses are provided for the operating staff.

New uses for electricity on the farm are being developed constantly as more and more farms are served by power lines, according to the United States Department of Agriculture. One of the newest developments is electrical heating of hotbeds. Several agricultural experiment stations have experimented with electric heaters and have found them practical. Electricity is also effective in dehydrating crops, and in California it has been found practical in dehydrating for the preservation of nuts.

Benson Boiler Tested for Steamship Service

AS HIGH-PRESSURE steam had proved successful in stationary plants the Hamburg American Line decided to take the unique step of testing how well such steam suits the heavy demand of a ship propulsion plant. In coöperation with the ship yard of Blohm & Voss, Hamburg, the Line equipped its 9000-t. cargo steamer Uckermark with a Benson boiler and two high-pressure turbines, which have been run on long trial

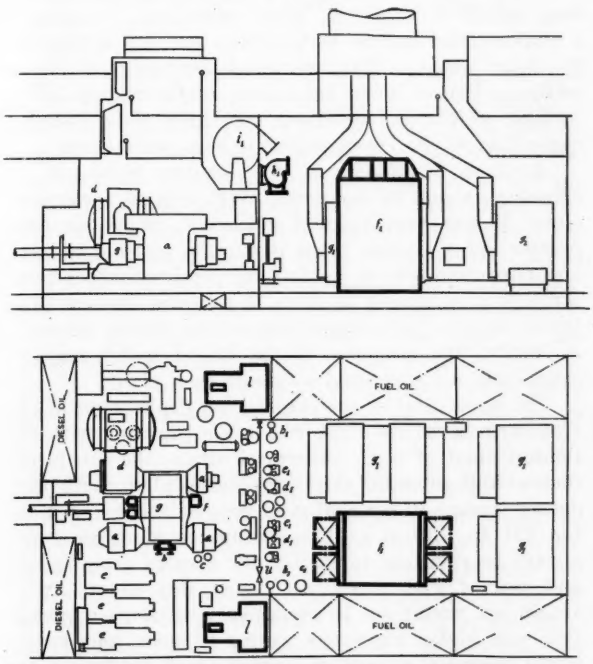


FIG. 1. ENGINE AND BOILER ROOM ARRANGEMENT OF S. S. UCKERMARK

a, regular forward and reverse turbines; *b*, control for 60 atmospheres-turbine (900 lb. per sq. in.); *c*, control for 15 atmospheres-turbine (225 lb. per sq. in.); *d*, main condenser; *e*, Diesel engine units; *g*, *f*, super-pressure turbines; *l*, high-pressure feed pumps; *u*, fuel oil pumps; b_1, economizers; c_1, feed water filter; d_1, fuel-oil preheaters; e_1, fuel-oil filters; f_1, Benson boiler; g_1, Scotch marine boilers.

trips of more than a year. Results of experience and tests with this plant are now available.

In order to incur but moderate expense for this testing plant and at the same time to have reserve plant aboard, if the high-pressure plant should prove unsatisfactory, an interesting arrangement was made. The new Uckermark was equipped with boilers and turbines taken from a ship of the Ballin class of the Line but, instead of two single-ended and two double-ended marine boilers only two single-ended and one double-ended marine boilers were installed. The other double-ended boiler was replaced by the Benson boiler, the high-pressure turbines being mounted on the top of the low-pressure turbines thus saving additional floor space. Fig. 1 at *g* and *f*.

It is a peculiarity of the Benson process, working at the critical point of water, that the boiler needs only remarkably small water content. For an output of 20 to 26 t. steam per hour, the Benson boiler of the Uckermark has a water and steam capacity of only 1 t. That proved advantageous when, in the start of the tests, some tubes broke because of a reason explained farther on. The small amount of water avoided explosions and other heavy damage, only the flame of the oil burners being blown out by the escaping steam.

Where they are exposed to radiation in the furnace, the material of tubes is molybdenum steel alloy. Economizer and superheater tubes are of rolled Siemens-Martin steel.

Originally ten oil burners, five on either side of the combustion chamber were installed in the Benson boiler. Since this failed to give uniform distribution of heat over the radiation surface of the tubes, the arrangement was changed so that now only four burners are on either side.

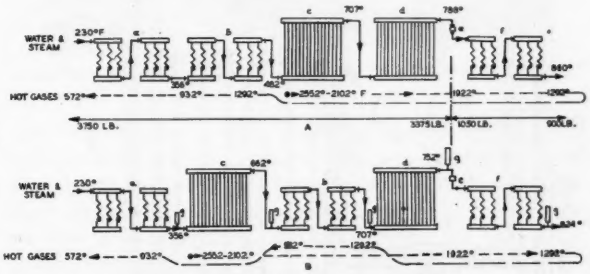


FIG. 2. ARRANGEMENT OF PIPE CONNECTIONS OF THE BENSON BOILER PLANT; A, ORIGINAL; B, FINAL

a, economizer No. 1, 1700 sq. ft.; *b*, economizer No. 2, 1700 sq. ft.; *c*, radiation boiler No. 1, 675 sq. ft.; *d*, radiation boiler No. 2, 675 sq. ft.; *e*, pressure-reducing valve; *f*, superheater, 800 sq. ft.; *g*, thermoelectric couples for temperature control.

Parts of the boiler are as follows; Fig 2: 2 economizers, *e* with 1700 sq. ft. each (158 sq. m.); 2 radiation sections *b* with 675 sq. ft. each (62.5 sq. m.); 1 superheater *d* with 800 sq. ft. (74 sq. m.) Total heating surface 5550 sq. ft. (515 sq. m.) Air preheater surface *f* 4256 sq. ft. (390 sq. m.).

Originally the series arrangement, with which the first trial trip was made, was as follows: Fig. 2A, economizers 1 and 2, radiation sections 1 and 2, superheater. As stated above, this arrangement caused breakage of some water tubes in the radiation section, due to the fact that, with this arrangement, the critical temperature of water was reached in the radiation section. Very rapid evaporation at this point prevented sufficient cooling of the pipes exposed to radiant heat so that they became overheated and gave way.

Connection of the boiler parts could be easily changed to the following arrangement, Fig. 2B, economizer 1, radiation section 1, economizer 2, radiation section 2, superheater. This brought the critical point of water in economizer 2 where the tubes are not exposed to radiant heat, so that breakage is now avoided.

Leaving the second radiation section, steam has a pressure of 3370 lb. per sq. in. (225 atmospheres) and a temperature of 752 deg. F. (400 deg. C.). Before it enters the superheater, passage through a reducing valve brings pressure to about 1050 lb. per sq. in. (70 at.).

*Abstracted from Journal Ver. Deut. Ing., Berlin, Nov. 21, 1931, pp. 1433-1437, Dr. Ing. E. L. E. Goos.

Steam enters the high-pressure turbine at 853 lb. and 860 deg. F. (460 deg. C.).

Pressure in the high-pressure part of the boiler is kept automatically at 3450 lb. (230 at.) by the pressure reducing valve which is operated by electric contacts

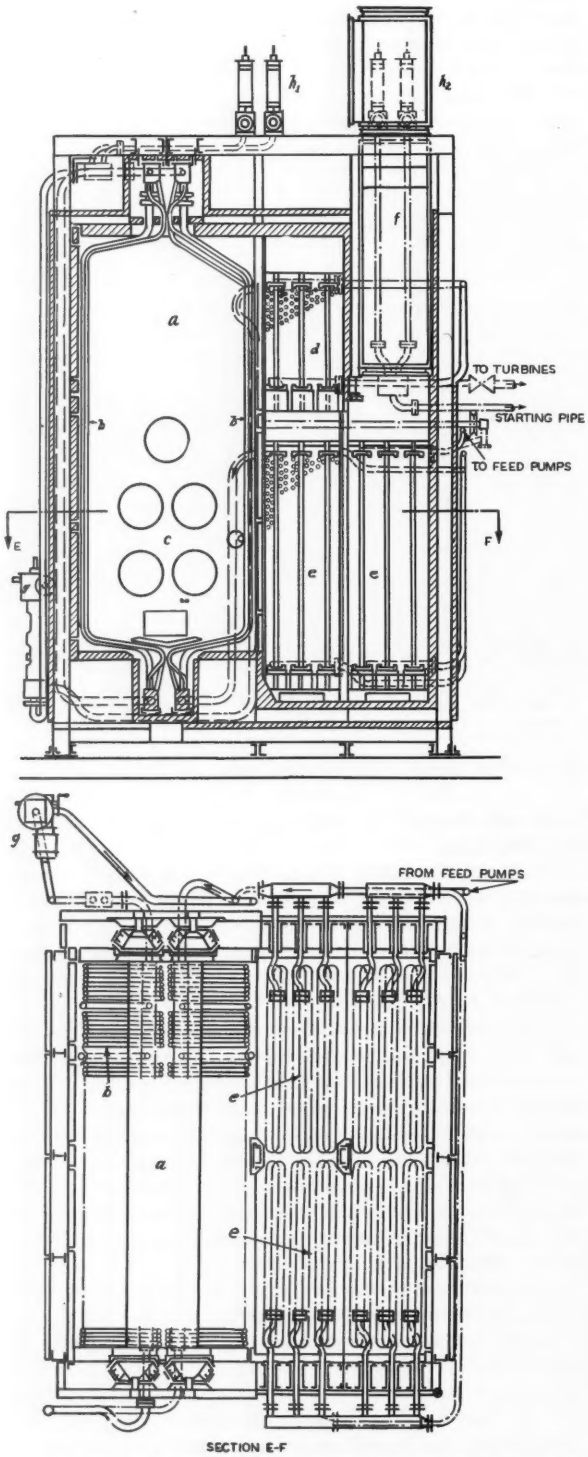


FIG. 3. BENSON BOILER OF THE HAMBURG AMERICAN LINER UCKERMARK

a, combustion chamber; *b*, water tubes; *c*, oil burners; *d*, superheaters; *e*, economizers; *f*, air preheater; *g*, control valve; *h*, safety valve for 3385 lb. per sq. in.; *h*, safety valve for 996 lb. per sq. in.; *f*, feed water inlet; *o*, steam to turbines; *s*, steam outlet for starting up.

but can, in emergency, also be operated by hand, mechanically as well as electrically.

Each high-pressure feedwater pump has six single-acting plungers in groups of three. Inlet and outlet valves are placed at some distance from the cylinders so that the water included between plungers and valves is in fact oscillating with the reciprocating plungers. This oscillating column of water itself acts as a plunger, so that the feedwater flows only through the valves of the pump, not through the cylinders. Passages of the pumps, in which the feedwater is oscillating are water cooled to carry away heat produced by friction of the oscillating water column.

The Benson boiler, Fig. 3, is about 20 ft. wide, 15 ft. deep and 20 ft. high. As before mentioned, it replaced a double-ended marine boiler which had but a third of its steam output. This marine boiler weighed 175 t. while the Benson boiler has a total weight of only 110 t., its light weight and small size making it to be a strong competitor of the Diesel engine in ship propulsion.

Another advantage of the Benson boiler is its efficiency, about 90 per cent. With a good turbine of about 75 per cent thermal efficiency, using the high pressure of a Benson plant it may be possible to burn not more than 0.48 lb. of fuel oil per horsepower-hour. Since fuel oil usually is 20 to 70 per cent cheaper than Diesel oil, the price depending on the harbor where it is bought, the economy of the Diesel motor may be equalled if not surpassed by the Benson plant.

Dr. Goos, chief of the engineering department of the Hamburg-American Line, who made the tests with the Benson plant of S. S. Uckermark draws the conclusion that a high-pressure ship propulsion plant with condenser is some 10 per cent more economical than a plant for 427 lb. (30 at.). This advantage alone may not always be sufficient to justify the greater complication and risk of a Benson plant, hence ship plants up to 15,000 hp. would not be equipped with Benson plants. But with higher capacities, saving of space and weight might become so advantageous that a high-pressure plant should be preferred.

Heat Content of Fuel

NATURAL GAS has a heat content considerably above that of manufactured gas and on a pound basis considerably more than other common fuels. In Hail Columbia, R. H. Burdick tabulated heat values of these various fuels on both the conventional unit and pound basis. These values are tabulated below:

	B.t.u. per conventional unit	B.t.u. per pound
Natural gas	1,100,000 per MCF	22,000
Manufactured gas	530,000 per MCF	11,500
Bottled gas	100,000 per gal.	21,500
Kerosene	126,000 per gal.	19,100
Gasoline	122,000 per gal.	20,100
Fuel oil	135,000 per gal.	18,000
Anthracite Coal	27,000,000 per ton	13,500
Bituminous Coal	28,000,000 per ton	14,000
Coke	27,000,000 per ton	13,500
Electricity	3,412 per Kw.	

Employing such a small unit as the B.t.u. leads to awkward figures when any considerable quantity of heat is under consideration and in the gas industry the therm, equal to 100,000 B.t.u., is being used to an increasing extent, thus the heating value of natural gas is 1,100,000 or 11.0 therms per thousand cubit feet.

Improving Plant Performance By Condenser Maintenance

DETAILS OF PROCEDURE WHEN ONE OR BOTH ENDS OF TUBES ARE ROLLED. USE OF BUSHINGS IN TUBE SHEETS THAT WERE MADE FOR PACKING. APPLICATION OF FERRULES AND TOOLS

WHEN CONDENSERS are being tubed, the procedure, if one or both ends are to be rolled, is somewhat different than when both ends are packed. The wooden cover* should be left in place on the outlet side with one end of the tube snug against it and the inlet end of the tube flush with the tube sheet. The inlet ends are first rolled or expanded with a tool similar to that used for expanding boiler tubes and then belled with a second tool. A typical motor driven expander with parallel rolls and the proper method of using it is shown by Fig. 1. The belling is done with the tool shown by Fig. 2 and should be sufficient to close the annular space at the end of the tube sheet. Two sharp blows from a 1-lb. hammer should be sufficient to do this.

TUBE SHEET AND TUBES SHOULD NOT BE DAMAGED

After this the board cover can be removed and the outflow end rolled or packed as the case may be. When expanding a joint should be made between the tube and tube sheet through the entire depth of the sheet. Neither the tube nor tube sheet should be distorted or damaged and the tube should not be gradually pushed into the tube sheet by the expanding tool to cause bowing later. Neither should the expander rolls be so short and sharp that they leave a shoulder as at A, Fig. 3. It is perhaps more than usual to find the tube sheet bored smooth and the tube expanded against this smooth surface as in Fig. 3, but helical grooves are sometimes cut in the tube sheet in order to increase the holding power of the expanded tube. A special tool for grooving the tube sheet is shown by Fig. 4.

*See Power Plant Engineering Sept. 15, 1930.

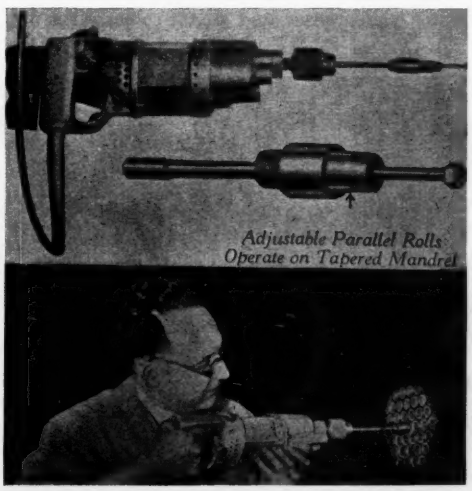


FIG. 1. EXPANDING TOOL AND DRIVING MOTOR (TOP) AND METHOD OF USING MOTOR DRIVEN EXPANDER (BOTTOM)

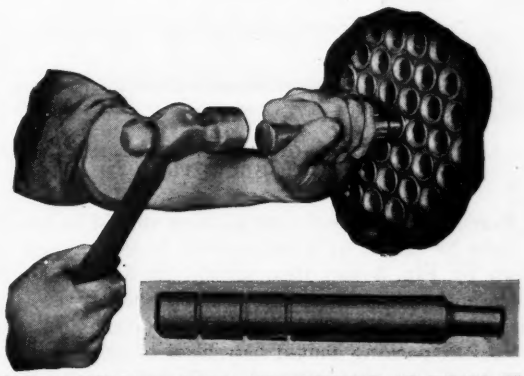


FIG. 2. BELLING TOOL AND METHOD OF USING IT

TO AVOID CRUSHED TUBES, BACK OFF FERRULES

This tool has a standard V thread, 40 to the inch, with the top of the thread ground off until it exceeds the diameter of the hole by 0.01 in. The root of the thread is smaller in diameter than the tube sheet hole. The tool can be used at high speed and leaves a groove 0.005 in. deep in the tube sheet into which the expanding tool forces the tube metal to a depth of 0.002 to 0.003 in. It is stated that tests show this method increases the holding power about four times and greatly reduces the amount of expanding necessary. In order to allow expanding of tubes in condensers when the tube sheet is already drilled for ferrules, special bushings can be purchased.* Bronze bushings which are screwed in and then faced off by a special tool. Fibre bushings are not threaded, but have a driving fit and are about ⅛ in. shorter than the depth of the stuffing box so as to allow the tube end to be belled after rolling.

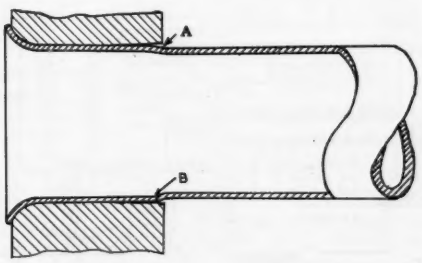


FIG. 3. IMPROPER EXPANDING TOOL CAUSES SHOULDER IN TUBE AND MAKES JOINT THROUGH ONLY A PORTION OF THE TUBE SHEET

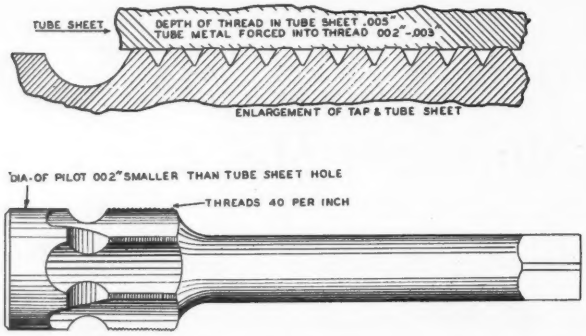

TUBE SHEET
DEPTH OF THREAD IN TUBE SHEET .003"
TUBE METAL FORCED INTO THREAD .002"-.003"
ENLARGEMENT OF TAP & TUBE SHEET
DIA. OF PILOT .002" SMALLER THAN TUBE SHEET HOLE
THREADS 40 PER INCH

FIG. 4. SPECIAL TOOL FOR GROOVING TUBE SHEET BEFORE EXPANDING TUBE

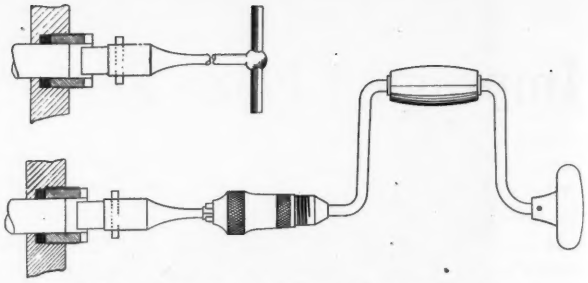


FIG. 5. TOOLS FOR INSTALLING FERRULES

Ferrules, when used with packing should be screwed in tight by means of a carpenter's brace or hand tool shown by Fig. 5 and then backed off a trifle because cotton and fibre packing swells after getting wet and if too tight will crush the tube. After packing is completed, the packing should be soaked overnight, preferably by filling the steam side of the condenser with water. If the condenser is set on springs or suspended from the turbine exhaust it should be blocked up as the weight of the water in the steam side is considerably more than the normal weight of water in the water boxes and tubes.

Leaks can be detected by going carefully over the tubes in each tube sheet and should be stopped by tightening up the ferrules, calking or expanding, depending upon the method of tube installation. Although leakage under these conditions is not the same as leakage in actual service it gives an indication of the condition and the water collected from the water box drain over a period of 6, 10 or 12 hr. can be used as the basis of an estimate of what can be expected in service. Other leakage tests are discussed in detail in the A. S. M. E. test code on condenser leakage or it can be determined by a commercial condenser leakage meter.

Addition to Riverside Station at Minneapolis

NORTHERN STATES POWER CO. ADDS NEW 35,000-KW. UNIT AND THREE STOKER FIRED 17,740 SQ. FT. BOILERS. STATION PRESSURE INCREASED TO 400 LB. GA., 750 DEG. F.

IN CONTRAST to general load conditions throughout the country, the Northern States Power Co. has shown a continuous increase, necessitating additional generating capacity in its Riverside Station at Minneapolis, Minn. This is one of the older stations on the system and, before the latest addition, had one 15,000 and two 28,500 kw. units operating at a pressure of 230 lb. ga., 600 deg. F. For the addition these steam conditions were changed to 400 lb. ga., 750 deg. F.

The new 35,000 kw., 14,500 v. General Electric turbogenerator, known as Unit No. 2, is at the north end of the building in the space formerly occupied by two 6000 kw. machines. Provision has been made to extend the turbine room north to accommodate another unit (No. 1) when load conditions warrant.

Steam is supplied by three stoker fired 17,740 sq. ft. Springfield boilers with 1066 sq. ft. of water walls, 3350 sq. ft. of combination radiant and convection superheater and a 12,096 sq. ft. economizer. Stokers, 14 retorts wide, 45 tuyere long, have a projected grate area of 487.22 sq. ft. each and burn Pocahontas screenings. The furnace volume is 10,600 cu. ft. with water cooled side walls, water and steam cooled back wall and

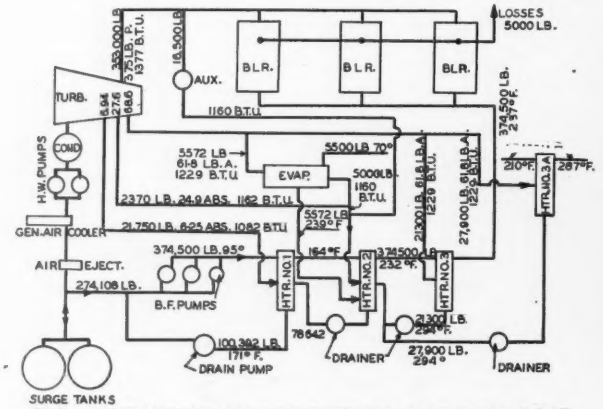


FIG. 1. HEAT BALANCE OF UNIT NO. 2 AT FULL LOAD

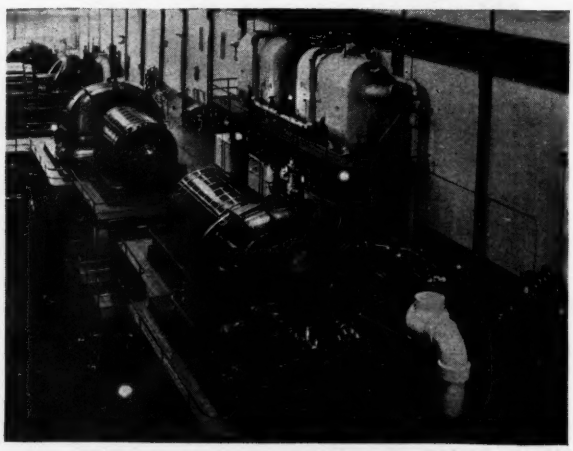
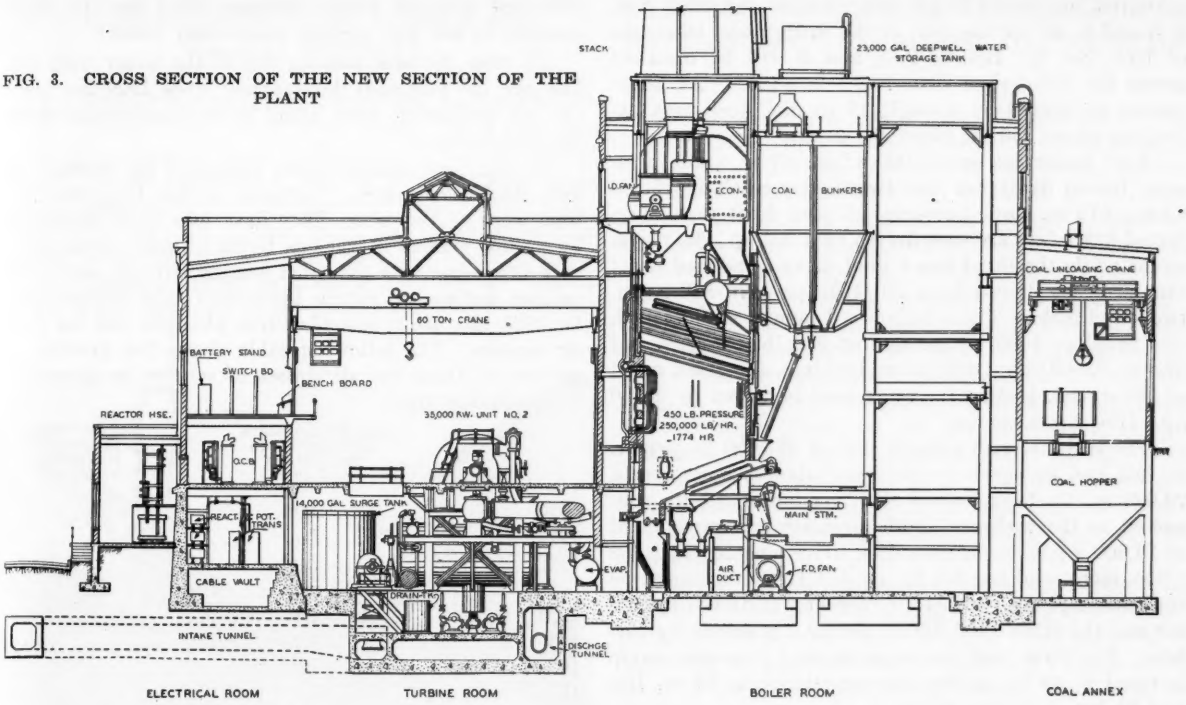


FIG. 2. (LEFT) TURBINE ROOM WITH UNIT NO. 2 IN THE FOREGROUND

FIG. 3. CROSS SECTION OF THE NEW SECTION OF THE PLANT



Mechanical Equipment Addition to Riverside Station

BOILERS, 3, Springfield Boiler Co. cross drum, 17,740 sq. ft., 450 lb. w.s.p. with Kellogg hammer welded drums.

SUPERHEATERS, 3, Foster Wheeler Corp. combination radiant and convection for 400 pounds steam pressure and 750 deg. F. steam temperature.

WATER WALLS, 3, Springfield Boiler Co., bare tube, 1066 sq. ft. per boiler.

ECONOMIZERS, 3, Foster Wheeler Corp., 12,096 sq. ft.

SAFETY VALVES, Crosby Steam Gage & Valve Co.

WATER COLUMNS, Yarnall-Waring Co.

SOOT BLOWERS, Diamond Power Specialty Co.

FIRE BRICK, Harbison Walker Refractories Co.

FRONT WALL, M. H. Detrick Co.

BLOW-OFF AND DRUMHEAD STOP AND CHECK VALVES AND NON-RETURN VALVES, Edward Valve & Mfg. Co.

FANS, 9, Buffalo Forge Co., one No. 10 Super Turbo forced draft fan per boiler, capacity 97,000 c.f.m., 70 deg. F., 6.7 in. of water, driven by 200 hp. 900 r.p.m. variable speed, Crocker-Wheeler motor. Two No. 9½ Super Duplex cinder eliminator type induced draft fan per boiler, capacity 85,750 c.f.m. at 8.72 in. of water, driven by 250/125 hp., 1170/870 r.p.m., Crocker-Wheeler motor.

STOKERS, 3, Westinghouse Elec. & Mfg. Co., 14-retort underfeed stokers with high side wall tuyeres and an overfeed section and double roll clinker grinders. Projected area 487.22 sq. ft. Maximum combustion rate 33,700 lb., Youghiogheny coal for 24 hr. period. Two 7½ hp., 1200/900/600/450 r.p.m. Fairbanks, Morse & Co. motors for clinker grinder. Stoker Drive, Waterbury Tool Co., variable speed drive with 30 hp., 600 r.p.m., American Electric Co. motor.

COAL HANDLING EQUIPMENT, Link-Belt Co.: Six track hopper gates; 36 in. apron feeder, 150 t.p.h. at 24 f.p.m. and 80 t.p.h. at 13 f.p.m.; 30 by 30 in. Peck carrier, 150 t.p.h. at 60 f.p.m., driven by a 30 hp., 900 r.p.m., American Electric motor; 30 in. belt conveyor with tripper, 230 t.p.h. at 300 f.p.m., driven by a 10 hp., 900 r.p.m., American Electric motor; 36 by 24 in. present apron feeder extension, driven by a 10 hp., 900 r.p.m., American Electric motor; 24 by 30 in. present Peck carrier extension, 80 t.p.h. at 50 f.p.m., driven by a 20 hp., 900 r.p.m., American Electric motor.

SPOUT SWINGER, 3, Coal Spout Oscillator Co.

ASH HANDLING EQUIPMENT, Allen-Sherman-Hoff Co., ash hoppers, sluiceway, clinker grinder, double roll, driven by 15 hp., 450 r.p.m., American Electric motor. Two float controlled vertical hydro-jet ash pumps driven by 100 hp., 900 r.p.m. Fairbanks Morse motors; ash pump discharging piping; ash storage bin of 10,000 cu. ft. capacity; one bilge pump, 1000 g.p.m. at 25 ft. head, driven by 15 hp., 720 r.p.m., American Electric motor; Hydrovac soot and fly ash system with windswept valves; hydro-vactor and Ashcolite piping.

ASH SLUICING PUMP, 2, Worthington Pump & Machinery Corp., 1300 g.p.m., 150 lb. discharge head, each driven by a 200 hp., 1750 r.p.m., General Electric motor.

FEEDWATER HEATERS, 4, Alco Products, Inc.; High pressure, 62 lb. abso. pressure in shell, 600 lb. in tubes, 1162 sq. ft., 4 pass.; high pressure, 62 lb. abso. in shell, 400 lb. in tubes, 1230 sq. ft. 4 pass.; low pressure, 6.25 lb. abso. in shell, 600 lb. in tubes, 1230 sq. ft., 4 pass.; auxiliary condenser, 26 lb. abso. in shell, 600 lb. in tubes, 1110 sq. ft., 4 pass.

HEATER DRAIN PUMP, 1, Pennsylvania Pump & Compressor Co., 240 g.p.m. at 25 ft. discharge head, driven by a 5 hp., 1800 r.p.m., General Electric motor.

BOILER FEED PUMPS, 3, Ingersoll-Rand Co., two No. 5 4 stage, 1000 g.p.m., 570 lb. discharge head, driven by General Electric 470 hp., 2400 r.p.m., type D-54, 2 stage steam turbines. One Cameron No. 4, 5 stage, 500 g.p.m., 570 lb. discharge head, driven by a Westinghouse 300 hp., 1750 r.p.m. motor.

EXCESS PRESS REGULATORS, 3, Mercon Regulator Co.

FEEDWATER REGULATORS, 6, Stets Co.

EVAPORATOR, 2, Alco Products, Inc., 256 sq. ft. heating surface evaporators, 5000 lb. of water per hr., 27 lb. abso. in shell, 62 lb. abso. in tubes.

SERVICE WATER PUMPS, 2, Ingersoll Rand Co., Cameron pumps. One No. 5 1000 g.p.m., 206 ft. discharge head, 2700 r.p.m. One 75 hp. Terry type ES steam turbine, driven by a No. 5 1000 g.p.m., 206 ft. discharge head, 1750 r.p.m., driven by a 75 hp. Crocker-Wheeler motor.

STRAINERS, Elliott Co.

BOILER WASH PUMP, 1, Worthington Pump & Mach. Corp., 160 g.p.m., 474 ft. head, 3550 r.p.m., driven by a 50 hp., 3600 r.p.m., American Electric motor.

PIPING, VALVES AND FITTINGS, Crane Co.

BLEEDER CHECK ATMOSPHERIC RELIEF VALVES—Atwood & Morrill.

EXP. JOINTS, E. B. Badger Co.

TURBO GENERATOR, 1, General Electric Co., 35,000 kw., 15 stage, 3 stage extraction, 1800 r.p.m., 375 lb. ga., 725 deg. F. total temperature with 1 in. back pressure. Generator 3 phase, 60 cycle, 14,500 volt with 180 kw. direct connected exciter and pilot exciter.

OIL FILTER, S. F. Bowser & Co., batch oil filter, pumps and 4000 gal. storage tank.

CONDENSER, Ross Heater & Mfg. Co., 29,000 sq. ft. single pass, steel shell for condensing 300,000 lb. of steam at 1 in. Hg. abso.

CONDENSER TUBES, PACKING, Scovill Mfg. Co., Crane Packing Co.

CIRCULATING WATER PUMPS, 2, Allis-Chalmers Mfg. Co., single stage, 335 g.p.m., 24,500 g.p.m., 17 ft. total head each operating together or 29,000 g.p.m. operating singly. One driven by a 200 hp. Allis-Chalmers motor, the other by a 175 hp. Terry type "GAATS," 3200 r.p.m. turbine with Terry U reduction gear.

CONDENSATE PUMPS, 2, Pennsylvania Pump & Comp. Co., 720 g.p.m. at 110 ft. total head, driven by a 50 hp. Allis-Chalmers motor. The other 800 g.p.m. at 110 ft. total head, driven by a 50 hp. Terry type ES turbine.

VACUUM PUMP, 1, Ross Heater & Mfg. Co., with three 2-stage elements, each element capacity of 49 lb. of dry free air with 80 deg. F. cooling water and 1 in. Hg. abso.

AIR COMPRESSOR, Ingersoll-Rand Co., type 20, single stage, single acting, vertical, duplex, with receiver, piston displacement 99 c.f.m., and discharge pressure 100 lb. per sq. in. Driven by a 15 hp., 900 r.p.m. General Electric motor.

BILGE PUMP, 2, Yeomans Brothers Co. No. 4 duplex auto-electric, 150 g.p.m., 28 ft. head, driven by General Electric 3 hp., 1150 r.p.m. motors.

BOILERS, PIPING, INSULATION, Smith Totman Co.

BOILER METERS, Bailey Meter Co.

DRAFT GAGES, Bailey Meter Co., Ellison Draft Gauge Co.

PRESSURE GAGES, Consolidated Ashcraft Hancock Co.

VACUUM GAGES, Taylor Instrument Co., C. J. Tagliabue Co., Foxboro Co., Brown Instrument Co.

a Detrick air cooled front wall. Boilers installed, Nos. 1, 3 and 5, all on one side of the firing aisle, take care of Unit No. 2. Boilers 2, 4 and 6 will be installed across the aisle when Unit No. 1 is added. All three boilers are served by a single 19 ft. dia. steel stack extending about 250 ft. above the grates.

Each boiler has one 97,000 c.f.m., 6.7 in. static pressure, forced draft fan and two cinder catching 85,750 c.f.m., 8.72 in. static pressure, induced draft fans. Two forced draft fans are each driven by a 200 hp., 900 r.p.m. motor while the third has a dual drive. Induced draft fans are each driven by a 250/125 hp., 1170/870 r.p.m. two speed motor. Three boiler feed pumps are installed, two rated at 1000 g.p.m. against 570 lb. pressure and driven by 470 hp. 2400 r.p.m. turbines, the third rated at 500 g.p.m., against the same head is driven by a 300 hp., 1750 r.p.m. motor.

The turbine, with a steam flow of 353,000 lb. per hr. at full load as shown by the heat balance, is set over a 29,000 sq. ft. Ross welded shell condenser solidly connected to the turbine. Both circulating pumps, rated at 24,500 g.p.m. each, have dual drive, one 200 hp., 360 r.p.m. motor and one 175 hp. geared Terry turbine. One condensate pump (360,740 lb. per hr.) is driven by motor and the other (400,000 lb. per hr.) is driven by turbine. The three unit, two stage steam jet vacuum pump is rated at 49 lb. of dry air per minute at 29 in. Hg. and 80 deg. F. cooling water.

Three stages of extraction are utilized for feed-heating and evaporator operation, the Alco closed heaters, evaporator and evaporator condenser hookup being shown diagrammatically in the heat balance. In addition to heating condensate from the unit itself, extracted steam from the first extraction point is used to raise the temperature of 350,000 lb. per hr. of condensate from the old section of the station from 210 to 287 deg. F. A closed feedwater cycle with a sealed surge tank between the condensate and boiler feed pump is used.

Output of the main unit may be split, part or all going to the Aldrich substation over 14.5 kv. cables and the remainder to the main 13,800 v. bus in the station through a regulating transformer. When the generator is shut down the Aldrich substation may be fed from the Riverside main 13,800 v. bus through the regulating transformer. Auxiliary power at 2200 v. is taken from two sources, one through a 3000 kv.a. 3 ph. transformer directly from the generator leads, the other from the regular 13.8 kv. station bus through either one of two banks of 2000 kv.a. three phase transformers.

Riverside was one of the 11 central stations covered in the Annual Review, Dec. 15, 1931, number of Power Plant Engineering and additional data regarding equipment is included in the tables on pages 1178-1205 of that issue. The station was designed and construction supervised by Byllesby Eng. & Mtg. Corp., Chicago, Ill.

Utilization of Waste Heat

MUCH PROGRESS in preventing waste of heat and in reclaiming heat that might otherwise be wasted is noticeable in the better plants during the past 10 yr. Most engineers realize the necessity of preventing steam and water leaks and of eliminating radiation losses by proper insulation. Better combustion equipment and improved furnace construction have aided in lessening such losses as are caused by air infiltration through boiler settings, loss due to combustible in ash and various combustion losses.[1]

To trap the heat passing out of the boiler with the flue gas, the principal development since 1920 has been the air preheater, used alone or in conjunction with the economizer.

In 1920 one manufacturer placed on the market its first steel economizers. Previous to that time economizers were of cast iron. They have now been developed by several makers in various forms of steel tubes, some with fins, some with extended heating surface, and with various designs of return bends and tube connections. In 1923 the above manufacturer also put out its first air heaters. The following table shows the growth in the use of these for all classes of service, as given by this manufacturer:

Year	No. Economizers sold relative to No. boilers sold, in %	No. Air Heaters sold relative to No. boilers sold, in %
1920	0.9	
1921	1.7	
1922	7.9	
1923	5.9	1.0
1924	4.4	4.8
1925	3.2	0.4
1926	7.2	3.3
1927	11.1	13.0
1928	12.6	12.6
1929	13.3	23.8
1930	10.7	21.5

It is impossible to generalize about the use of such equipment. Fuel cost, operating hours per year, efficiency gained by use of economizers and air heaters, or both, are some of the factors involved in analyzing the savings in fuel made by these.

Air preheaters have taken various forms: rotary element, tubular, plate, fluid heat transfer. Cost of ductwork, control of air temperatures, maximum air temperatures, gas temperatures as related to dew point and other factors involved in their design have received much study. Typical air preheater studies[2] show gains in efficiency due to air preheating of from 5½ to 7 per cent. Economizer studies[3] show typical returns on investment due to economizers of 10 to 15 per cent, depending on the individual conditions of each plant.

Utilization of heat in exhaust steam has also received much attention since 1920. It is used in heating systems, air conditioning systems, unit heaters, open feedwater heaters and some forms of deaerating heaters, hot water generators for process work and most engineers now appreciate the importance of using it wherever possible. Heat in blowdown water from boilers is frequently saved by heat reclaimers and put into cooler water instead of being discharged to the sewer. Hot condensate, such as drips from heating coils, heating systems, trap discharges and so on can be reclaimed by various forms of condensate control and receiver systems developed in recent years. Various heat economizers and waste heat boilers have been developed for utilizing heat acquired by jacket water of Diesel engines and the heat of the exhaust gas.

[1] Conditions Propitious for Heat Savings, Power Plant Engineering, page 15, Jan. 1, 1930.

[2] Reclaiming Heat From Flue Gas, Ibid, page 42, Jan. 1, 1930.

[3] How Do You Select Your Economizer, Ibid, page 1214, Nov. 1, 1930.

Coal Handling Costs In Small Plants

OPERATING COSTS of a small coal unloader at the Chicago Yard No. 2 of the Silver Creek Coal Co. have been compiled by A. C. Nielsen Co. The equipment shown in the photograph consists of a Fairfield track feeder and portable flight conveyor. The feeder, operated by a 5-hp., 220-v., 3-ph. motor, has been in operation about 5 yr. and the conveyor, 40 ft. in length, with a 16-in. conveyor trough and driven by a 7½-hp., 220-v., 3-ph. motor, has been in use about 2 yr.

TRACK LOADER AND PORTABLE CONVEYOR IN OPERATION

Most of the cars are unloaded directly to bins but about 150 cars a year are handled by the above equipment. Unloading time of hopper bottom cars varies with the coal handled. A 55-t. car of Pocahontas mine run can be unloaded in 1¾ hr. and egg coal in considerably less time. One man is required for operation.

In figuring the costs in the accompanying table, depreciation was figured on an expected life of ten years and interest at 6 per cent. Including freight and cartage, the feeder cost $650 and the conveyor $1000. Two years ago, the feeder was returned to the factory and rebuilt at a cost of $50, the only charge in five years. No maintenance has been required on the conveyor but a yearly allowance of $20 has been made for both pieces of equipment. An additional $5 was allowed for lubrication. Labor has been figured as $0.60 per hour and power (12½ hp.) at $0.02 per kw-hr. This brings the operating charges to $1.38 per car or $0.0251 per t.

General data	
Size of car unloaded, t.	55
Unloading time, hr.	1¾
Unloaded per hr., t.	31
Unloaded per year, cars	150
Investment	$1650
Annual charges	
Depreciation, 10 yr. life	$165.00
Average interest at 6 per cent	54.45
Repairs and maintenance	20.00
Lubrication	5.00
Total	$244.45
Unloading cost per car	
Annual charges $244.45 ÷ 150	$1.63
Power 9.3 kw. × 1¾ hr. × $0.02	.33
Operator 1¾ × $0.60	1.05
Total	$3.01
Unloading cost per ton $3.01 ÷ 55	$0.055

Gatineau Seventh 34,000-Hp. Generator Installed in Paugan Hydroelectric Plant

GATINEAU POWER Co., a part of Canadian Hydroelectric Corp., Ltd., has completed the installation of the seventh 34,000-hp. generator in its Paugan, Quebec, hydroelectric plant. With the addition of this unit, Paugan now has an installed capacity of 238,000 hp. and ranks as one of the largest hydroelectric generating stations in North America. As the Paugan powerhouse can house eight 34,000-hp. generators, the installation of the present seventh unit involved only the cost of the machinery, resulting in comparatively low additional capital cost per horsepower. Installation of the new unit raises to 472,500 hp. the aggregate installed capacity of the company's plants on the Gatineau River, and increases to 575,119 hp. the interconnected capacity of all its stations on the Ottawa River, Gatineau River and other tributaries. In addition, the company has 104,400 hp. in other hydroelectric plants, making a grand total of 679,519 hp.

The turbine, manufactured by Dominion Engineering Works, is a vertical shaft, single Francis type runner, plate steel casing turbine, having a rated capacity of 34,000 hp. at a net effective head of 132 ft. and at 125 r.p.m. It is a duplicate of the present units with the exception of the runner and lower distributor ring, which are somewhat larger and the draft tube, which has been modified to give slightly higher efficiency. Total weight of the turbine including the steel plate scroll case and the governor system is 472,000 lb. Overall height of the runner and shaft is 19 ft., 3 in.; the maximum diameter of the runner is 11 ft., 11 in. and its height 5 ft., 9 in. A Woodward governor is used.

The generator of the new unit was supplied by Canadian Westinghouse Co. and is rated 28,500 kv-a., 85 per cent power factor, three-phase, 6600 v., 25 cycles, 125 r.p.m. It is vertical, with direct-connected auxiliary generator rated 300 kv-a. and direct-connected pilot exciter rated 21 kw. It is an exact duplicate of the other six generators in the plant. On the same contract, Canadian Westinghouse supplied the connecting material for the excitation system and the remaining control equipment which was not installed with the original development. A rheostatic type voltage regulator is used and the speed of response of the excitation system is 400 v. per sec.

Three single-phase, 19,000-kv-a., 25-cycle, 6600-v. to 220,000 v. transformers are of the non-resonating type and are the first of this type built by the Canadian General Electric Co. in Canada. The transformers are operated with the neutral grounded but neutral insulation for 73 kv. has been provided.

One 230-kv. oil circuit breaker has been installed. This was supplied by Canadian Westinghouse Co. and is rated 600 amp. with a rupturing capacity of 1,750,000 kv-a. This breaker is equipped with deion grids and is expected to clear a vault in 3½ cycles 0.14 sec.

CONGENITAL COLOR blindness, according to Forrest Clements, occurs in three chief forms. Most common is that in which red and green are confused. In a rarer form all colors are confused and in the third form, which seldom occurs, blue is confused with yellow.

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Power Utilization

Induction Motor Operation at Abnormal Voltages

Effects of Under and Over Voltage on Power Torque, Losses and Efficiency. By A. C. Roe

QUITE OFTEN it is necessary to operate induction motors on line voltages that are either above or below the standard name plate rated line voltage and the question arises as to what effect the voltage variation has on the motor's performance.

Major items of alternating current motor performance can be listed as: (1) Power factor; (2) efficiency; (3) horsepower; (4) slip; (5) speed; (6) starting torque; (7) maximum torque; (8) heating, which is composed of copper, stator and rotor, core, windage, and friction losses; (9) magnetizing current; (10) starting current; (11) full load current.

All the preceding factors are affected to some extent by changes in the line voltage. The amount of effect will vary in different motors or designs, therefore the figures given here, from tests on a given motor, are indicative only of the general results that can be expected. Data are given for 10 and 25 per cent variations in line voltage.

10 Per Cent Over Voltage

The following indicates the effect on a 50-hp., 860-r.p.m., 60-cycle motor when operating on 10 per cent over voltage:

(1) Power factor was reduced approximately 1¼ per cent, due to an increase in magnetizing current. The wattless current is dependent upon the leakage and upon magnetizing current which is generally 1½ to 3 times the leakage current and varies as the square of the voltage.

(2) The efficiency was increased approximately ¾ to 1 per cent. The increase or decrease in any case is dependent upon whether a decrease in copper losses offsets an increase in core losses. The copper losses are generally less, as the full load current is decreased with over voltage and for the same horsepower output.

(3) The figures for change in horsepower capacity given are based on full load rating but the overload capacity is increased.

(4) Slip was decreased approximately ¾ to 1 per cent, due to less rotor copper losses, thus the speed is increased. The slip for the same power rating and apparent efficiency varies inversely as the square of the voltage.

(6) Starting torque was increased 20 per cent, since it varies nearly directly as the square of the applied voltage.

		OVERVOLTAGE				UNDERVOLTAGE					
		10%		25%		9.1%		27.3%		5.5%	
		+%	−%	+%	−%	+%	−%	+%	−%	+%	−%
1	POWER FACTOR		1¼		4.7	¾				⅛	
2	EFFICIENCY	¾		1			1.4		6⅞	00	00
3	HORSEPOWER CAPACITY	✓		✓			✓		33		✓
4	SLIP		¾		35½	21		90		12	
5	SPEED R.P.M.	✓		✓			✓		✓		✓
6	STARTING TORQUE	20		141¼			18		50		11
7	MAXIMUM TORQUE	20		153¼			18		50		11
8	TOTAL LOSSES		6		10	14½		73		4½	
	STATOR COPPER LOSS'S		17		27½	22¼		117		11	
	ROTOR COPPER LOSSES		17½		31⅓	23¾		97		12½	
	IRON OR CORE LOSSES	18		50			15½		45½		11¼
9	MAGNETIZING LOSSES	20		75			17.5⅛		50½		8½
10	STARTING CURRENT	10		25			9		✓		5½
11	FULL LOAD CURRENT		✓		✓	✓		✓			✓

CHANGES IN MOTOR PERFORMANCE DUE TO OVER OR UNDER VOLTAGE

(7) Maximum torque was also increased 20 per cent, varying about as the square of the applied voltage.

(8) Heating or temperature rise was less, as in this case the copper losses offset the core or iron losses, or the total losses were lower by some 6 per cent. In this case the core losses increased 18 per cent. Friction and windage remained the same and the copper losses were as follows: Rotor 17½ per cent less, stator 17 per cent less. The rotor copper losses were less, due to the smaller current required for the same power.

(9) Magnetizing current, expressed as a per cent of the total current will increase in direct proportion to the square of the voltage, for motors in which the iron is worked well below the saturation point. In this case the magnetizing current was increased from 23.6 per cent to 28.5 per cent, or 20 per cent increase.

(10) Starting or locked-rotor current was higher, due to higher voltage.

(11) Full load current was less, as it is dependent upon (hp. × 746) ÷ (Square root of 3 × Line Voltage × Power Factor × Efficiency). Thus with lower line voltage, higher efficiency and power factor, the full load current must decrease.

The preceding data indicate how 10 per cent higher voltage affects the various factors at full load. On fractional loads such as half load, however, the magnetizing current will be almost doubled. The iron and friction losses which are practically constant will exceed the copper losses, thus reducing the efficiency and decreasing the power factor to a greater degree.

25 Per Cent Over Voltage

Following are figures to show the effect on various characteristics, in percentages giving the differences be-

tween normal and 25 per cent over voltage. Thus over voltage greater than 10 per cent will vary the performance over a wider range. At 25 per cent over voltage the magnetizing current has increased considerably, the cores being worked past magnetic saturation thus greatly reducing the power factor; the iron losses being higher might cause the motor to run hot regardless of the reduced copper losses. Thus there is a point for each motor beyond which it is impossible to increase the line voltage for safe operation. (1) Power factor, 4.7 per cent less; (2) efficiency, 1 per cent increase; (4) slip, 35 per cent decrease; (6) starting torque, 14¼ per cent increase; (7) maximum torque, 15¾ per cent increase; (8) total losses, 10 per cent less, stator copper losses 27½ per cent less, rotor copper losses 31⅓ per cent less, iron losses 50 per cent increase; (9) magnetizing current, expressed as a per cent of the total increased 75 per cent or from 23.6 per cent to 41 per cent.

Thus these figures offer a means of studying the possible effect and whether the motor would operate satisfactorily under conditions prevailing with 25 per cent over voltage. It is also apparent that over voltage provides a means for slightly reducing the temperature of overloaded motors at the expense of a lower power factor and higher starting current.

Under Voltage

Motors operated on voltages less than standard name plate rated line voltage, have the starting and maximum torques reduced, and also the horsepower capacity is lowered, as the following figures derived from tests on standard motors will indicate.

Figures are given for voltages 9.1 per cent, 27.3 per cent, and 5.5 per cent below normal. The last percentage applies to 220-v. motors operating on 208 v.

First, considering the 9.1 per cent under voltage data we find that: (1) Power factor was increased some 7/10 of 1 per cent; (2) efficiency reduced 1.4 per cent; (3) power capacity reduced due to increased copper losses, reduced torque, etc.; (4) slip increased 21 per cent, due to increased rotor copper losses, hence the speed was reduced; (6) starting torque, which varies with the square of the applied voltage, was reduced 18 per cent; (7) maximum torque was also reduced 18 per cent; (8) total losses were increased about 14 per cent; of this total the stator copper losses increased 22¼ per cent, the rotor copper losses increased 22¾ per cent, and the iron losses decreased 15½ per cent; (9) magnetizing current was reduced from 24.9 per cent to 20½ per cent or a reduction of 17⅝ per cent; (10) starting current was reduced in direct proportion to the voltage reduction, or 9 per cent; (11) full load current was increased with reduced line voltage.

Operating on 27.3 per cent under voltage, the same motor has the performance affected as shown in 7th and 8th columns of the Table. Thus, 27 per cent under voltage reduces the efficiency; the starting and maximum torques are reduced 50 per cent; the magnetizing current is reduced but the power factor remains practically the same. The power capacity is reduced 33 per cent due to the large copper losses which would cause excessive temperature rise.

Operating at 5½ per cent under voltage has the effects listed in the last two columns, the efficiency being affected little or none and the other characteristics so little that it can be considered satisfactory to operate.

In general, the data in the Table would indicate that operating an induction motor on 5, 7 or 10 per cent under or over voltage should not seriously affect its performance and even up to 15 per cent it is possible, in some cases, to get by for a short time.

When any motor operates on voltages above or under standard and it is known that this condition will exist for a long time, such as running 220-v. motors on 208-v. network, it should be kept in mind when the motor is rewound, so that the winding can be redesigned to suit conditions and to improve those items listed in the Table, that are deemed the most essential.

Motor Brushes

CONSIDERATIONS in selecting brushes are to secure long life to the commutator, long life of brushes and good contact to reduce contact resistance. Conditions vary on different motors so that trial and observation are often needed to determine the kind of brush best fitted to each. It is desirable, too, that the kinds of brushes carried in stock in a plant be as few as possible.

Grades of brushes are rated on the following characteristics: Hardness, or resistance to wear; abrasiveness of tendency to wear away the commutator; current capacity in amperes per square inch without undue heating; contact drop in voltage where brush meets commutator; coefficient of friction of brush rubbing on commutator; specific resistance to passage of current through the material of the brush.

Long commutator life requires that a solid glazed surface, brown in color, be maintained. This can be achieved only by freedom from sparking and a certain amount of graphite in the brushes to give a lubricating effect. Where heavy peak loads or much vibration are encountered, it may be difficult to find a brush that will give the glaze wanted. The best that can be done is to come as near it as possible.

Grades of brushes are offered in great numbers, the chief variation being in the proportions of carbon and graphite used. Graphite makes for good contact, low resistance and small friction. Carbon makes for long life but greater resistance. It is possible, however, to reduce contact resistance so low that sparking is increased due to short circuit current through the brush face during commutation.

Compromise is necessary to harmonize the life, friction and resistance requirements. Consultation with the brush maker, then trial to determine what grades give best results will result in securing the best possible operation. Use of whatever comes first to hand will not. And it may be the cause of large expense in commutator repairs.

The Upward Trend of the Boiler Room

IN DISCUSSING boiler capacities on page 17 of the January 1 issue, it was stated that the double boilers at Hell Gate had already made over 1,250,000 lb. of steam per hour, whereas these boilers have made only somewhat over 1,100,000 lb. per hr. of steam. The statement should have referred to the double Ladd boilers at East River station, which have produced over 1,250,000 lb. per hr. of steam and which were described and illustrated in the article, The Power Behind New York, page 892, September 1, 1931, issue.

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Service Water Heater Essentials

STEAM CIRCULATION, HEAT TRANSFER, CONDENSATE REMOVAL, AIR BINDING ARE IMPORTANT

DEMAND on storage heaters is usually widely fluctuating. For process work, for showers and cleaning up at the end of a day's work, lots of hot water is wanted, "right now". Again, for considerable periods. draft of water may be small or none.

Where heating is by steam, as is usual in factory plants, evidently storage capacity must be of volume

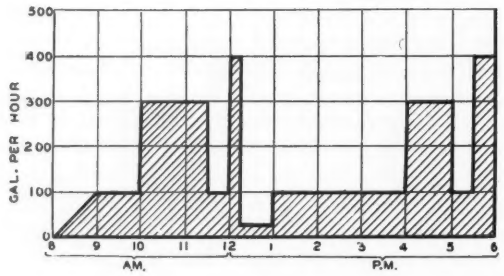


FIG. 1. WATER DEMAND FOR A FACTORY PLANT

to meet the largest peak demand since instantaneous heating is possible only by direct mixing of steam with the water, a method liable to result in uncertain temperature of the hot water.

Rapidity of heating needed will depend on the time interval at which peak demands succeed one another but it is usual to provide rapid heat transfer by means of thin walled steam coils of ample area so that plenty of water will always be available. So far as heat energy is concerned, there is no gain by slower heating, except for the saving in radiation loss, which is negligible for well insulated tanks.

TANK SIZE

Assume, for instance, that a plant requires steady supply of 100 gal. an hour for process work with a heavy demand from 10 a.m. to 11:30 a.m. of 300 gal. an hour and from 4:00 p.m. to 5 p.m. of the same amount; wash requirements are from 12 m. to 12:10 at the rate of 400 gal. an hour and the same rate from 5:30 p.m. to 6 p.m. The demand curve will then be as in Fig. 1. Water is to be delivered at 200 deg. F. and steam supply is at 10 lb. gage. Cold water enters the tank at 55 deg. in winter.

Peak demand is evidently the evening wash period when 200 gal. are drawn, or $200 \times 8.33 = 1666$ lb. As this is heated from 55 to 200 deg., a range of 145 deg., the heat needed is $1666 \times 145 = 241{,}570$ B.t.u. Steam will be condensed, giving up its latent heat, 952 B.t.u. per lb. and will have temperature of 239 deg. The steam to be condensed would be, therefore, $241{,}570 \div 952 = 2535$ lb. The heat transfer rate, if water were heated as fast as drawn would be 483,140 B.t.u. an hour. For this period, however, it would be no great matter if delivered-water temperature fell off somewhat. If water is fed to the bottom of the heater and drawn from the top, nearly the tankful could be used with small drop in delivered temperature, hence, with a 400-gal. tank, the heat supply rate could be much less than the peak heat consumption rate.

For the morning heavy demand period, since it lasts for 1½ hr. and is for process work where maintaining temperature will be essential, the rate of heat supply should equal the heat withdrawal. At 300 g.p. hr., this is:

$$300 \times 8.33 \times 145 = 362{,}355 \text{ B.t.u. an hour.}$$

Supplying heat at that rate during the 5:30 to 6 p.m. period, the excess of heat rate delivered over that supplied would be, $(483{,}140 - 362{,}355) \div 2 = 60{,}392$ B.t.u. per hr. or 30,196 in ½ hr. For the 400-gal. tank this would at most cause a temperature drop of $30{,}196 \div (400 \times 8.33) = 9$ deg. or to 191 deg., which is amply warm for washing.

Volume required for 400 gal. of water is $400 \times 0.1337 = 53.48$ cu. ft. In addition, space must be provided for the heating coils, which should next be considered.

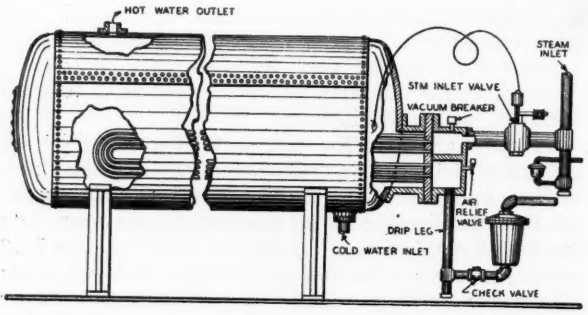


FIG. 2. AUXILIARIES AND ARRANGEMENT FOR EFFECTIVE HEATER PERFORMANCE

HEATING COILS

Heating surface is needed to transmit, from 10 a.m. to 11:30 a.m. at the rate of 362,355 B.t.u. an hour. This will depend on the metal used for coils and the mean temperature difference, as well as on the surface provided but, for safe design, a transmission of 300 B.t.u. per sq. ft. per hr. per degree of temperature difference may be taken, if iron or steel coils are used. For copper coils, this rate might be raised to 400 B.t.u.

As to mean temperature difference between steam and water, experiments have shown that use of the arithmetical average of water temperature gives incorrect results; for the conditions here used, the error would be some 19 per cent. This difference should, therefore, be calculated by the method developed by Poole as follows.

$$D = (F - I) \div (\text{hyp. log. } [(S - I) \div (S - F)])$$

Where D is mean temperature difference; F and I are final and initial temperatures of the water; S is the temperature of the steam. For our conditions, F is 200 deg., I is 55 deg.; S is 239 deg.

Substituting in the formula:

$$D = (200 - 55) \div (\text{hyp. log. } [(239 - 55) \div (239 - 200)])$$

The value of $(239 - 55) \div (239 - 200)$ is 4.715 and from tables, hyp. log. of 4.715 is 1.55. The value of D works out to 93.6 deg. F.

Heat transmission per hour will then be:

$$362{,}355 = A \times 300 \times 93.6$$

or area, $A = 362{,}355 \div (300 \times 93.6)$, which gives a value of A = 12.9 sq. ft. of coil surface.

If 1-in. pipe be used, it will require, as given in pipe tables, 2.9 ft. of pipe per sq. ft. of external surface, or, for 12.9 sq. ft., 37.4 ft. of pipe will be necessary. The volume of 1-in. pipe is 0.0094 cu. ft. per foot length, hence 37.4 ft. will occupy 0.352 cu. ft. With return bends and connections, 0.5 ft. should be allowed.

This, added to the 53.5 cu. ft. for water gives 54 cu. ft. as the needed volume of the heater shell. If a horizontal shell is to be used, a long, small-diameter will give maximum contact of water with coils and rapid heating, while a short, large-diameter will be better for storage and even delivery temperature during peak demand. For convenience in manufacture, installation and use a compromise might be for a length about twice the diameter.

Actual dimensions can most quickly be determined by a series of trials. For instance, if 6 ft. long be assumed, cross section will be $54 \div 6 = 9$ sq. ft. This calls for 3.4 ft. diameter. If 5 ft. length be taken, cross section will be 10.8 sq. ft. and diameter 3.7 ft. For 7 ft. long, section will be 7.7 sq. ft. and diameter 3⅛ ft. For 8 ft. long, section will be 6.75 sq. ft. and diameter 2.95 ft.

To get 37.4 ft. of pipe in three return bend coils will need 6.23 ft. of length, which will fit into a 7 or 8-ft. shell length. If four return bends are used, coil length would be 4.67 ft., which would go in a 6-ft. long shell. The choice would be governed by space available for the heater or, perhaps in this instance by the faster heating of an 8-ft. long heater during the 5:30 to 6 p.m. peak.

Auxiliary Equipment

Arrangement similar to that of Fig. 2 may be used, provision being made for bottom cold water inlet, top draw off, attachment of heating coil assembly near the cold water inlet, clean out manhole at the other end, also for supply of steam to coils and removal of condensate.

Steam supply should be controlled by a thermostatic valve, the thermostat located away from the heating coils and well down on the tank. To avoid formation of vacuum by condensation of steam after the steam valve closes, a vacuum breaker is placed on the steam inlet header box, while on the outlet box is an air relief valve to carry away air which will enter through the vacuum breaker and might cause air binding, if not disposed of quickly when steam starts to flow into the coil.

Condensate flows to a drip leg which is drained by a trap, with check valve to prevent backing up from the trap into coils when steam pressure is shut off. Also, to ensure that only dry steam goes to the coils, a drip leg and small trap are provided on the steam inlet.

For effective performance, the air relief valve and the trap for condensate must be of size to remove air and water quickly under the greatest demands that can be made on them, so that full benefit of the heating surface may be maintained. For instance, T. H. Rea gives the rule that a pound of steam will be needed for each 100 gal. of water raised 1 deg. F. To raise 300 gal. 145 deg. will call for $3 \times 145 = 435$ lb. of condensate to be removed in an hour. Mr. Rea recommends that the trap be of capacity to handle three times normal load on account of the conditions to be met from rapid drawing of water with consequent abnormal condensation of steam by the cold water inrush and the reduced pressure available to empty the trap, consequent on this rapid condensation. In other words, a trap with capacity of 1305 lb. an hour should be used, so that water can never collect in the coils to cause water hammer and possible rupture. One case is cited where two traps were installed, one set to open at normal pressure, the other to come into action at the lower pressure resulting from overload demand.

Capacity of the drip leg too must be sufficient to hold all condensate that can accumulate while the trap is emptying and again Mr. Rea recommends provision for three times the amount expected for maximum operation. Pipe between the heater and the trap should be of full size of the heater outlet.

It is not the idea that it will be good business to build a homemade heater but the foregoing will give the means of determining what should be provided, whether a proposed heater will do the job and whether proper installation has been provided to ensure satisfactory performance.

Less Cost for Pulleys and Belts

By W. F. Schaphorst

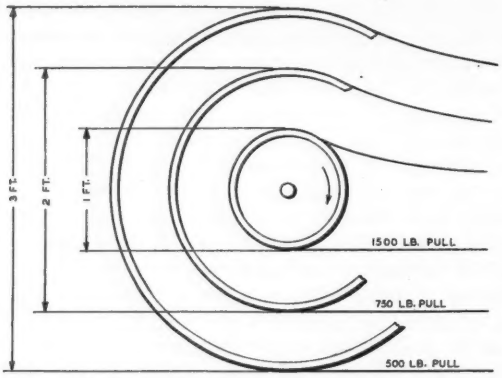
GRADUALLY, machinery designers and users are coming to see that large diameter pulleys are almost invariably more economical than small ones as regards both first and ultimate cost.

In the old days, machine builders habitually used small pulleys, reasoning, apparently, that they looked better, since the small pulley looks economical and innocent, while the large one seems to say, "I am expensive and maybe wasteful. Watch out." The big pulley might look to the buyer to indicate large power needed to drive the machine.

But, because the manufacturers used small pulleys, trouble sometimes resulted. The belt slipped, wore, ran off or broke. Were the pulleys blamed? Decidedly not. The belt was to blame. It is not surprising that individual electric motor drive went over big as a method of doing away with belts.

Large Diameter Reduces Belt Pull

Herewith is a sketch which shows clearly why large pulleys are preferable to small ones. In the center is a pulley 1 ft. diam. To transmit a given load the belt must exert a pull of 1500 lb. which means that the corresponding pull on the bearing at each end is some 2500 lb. Now let us double the diameter of the pulley and run the shaft at the same speed. It is obvious that the pull required drops from 1500 to 750 lb. Therefore



RELATION OF PULLEY DIAMETER TO BELT PULL

the corresponding pressure against the bearing at each end is only some 1250 lb. Again, assuming that the belt speed will not exceed a mile a minute, it may be practicable to increase the pulley diameter to 3 ft. The pull then drops to 500 lb., which means that the pressure exerted against the bearing at each end is only some 625 lb.

But that isn't all. With each increase in pulley diameter there is a corresponding reduction in belt width needed. Thus the belt on the largest pulley may be only one-third as wide as that on the smallest pulley, meaning that the cost of the belt will be reduced to one-third.

Motor vs. Pulley Size

While on the subject of pulley diameter, have you ever seen a pulley on an electric motor which was larger in diameter than the motor itself? Even today motor manufacturers seem to think that the diameter of the pulley on a motor must be less than the diameter of the motor. They probably feel that a pulley larger than the motor itself wouldn't look right. There is no reason in the world why pulleys should invariably be smaller than motors. A pulley twice the diameter of the motor might look peculiar but what of it? Of course there is a limit to the economical speed of a belt. Ordinarily the speed should be no greater than a mile a minute, as already stated. For that reason, on high-speed motors it is obvious why pulleys must necessarily be small. On slow-speed motors, however, the pulley should be as large as possible for the reasons previously discussed.

Operating Standards for Ice Plants

Some Aids to the Operating Man to Help Him Discover Leaks as Outlined to the National Association of Ice Industries at the San Antonio Convention. By H. L. Lincoln*

AS AN INDICATION of what might be accomplished, the following short key to good operating practice is submitted for the use of those who wish to know how the operations of any particular ice plant compares to one of recent design, or as a measurement of the economy of the investment. By frequent use of the figures as listed in checking operations, the plant engineer can learn when adjustments are necessary or plan betterments, so that he can obtain the maximum amount of ice from the machinery installed, at the minimum cost.

*Chief Engineer, Union Ice Co., San Francisco, Cal.

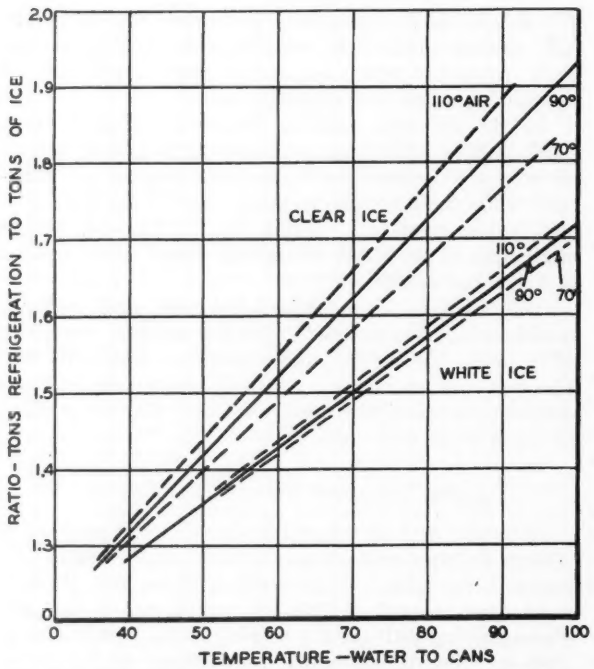


CHART SHOWING THE RATIO OF TONS OF REFRIGERATION PER TON OF ICE AS A FUNCTION OF WATER AND AIR TEMPERATURE

To compare intelligently the operations of several factories, it is necessary to make sure that they are of similar design, do the same kind of work, have similar load factors and work against the same temperature of air and water. A large season storage means an increase in power and labor; if water is supplied from a well, the power used depends on the distance the water must be pumped; while a high pressure air system uses more power than a low. It therefore seems desirable to establish an "average" plant before discussing its operation.

It may be assumed that the storage has space for not over a week's production, a low-pressure air system is used and the condensing water is only pumped once, either being recirculated over a tower, or lifted not over 40 ft. from a well. As the character of the water to be frozen sets up definite limitations to factory operations, the composition of raw water "suitable for ice making" must be known if a performance standard is to be established. Throughout this paper, it is assumed that the water has not over 250 p.p.m. (15 g.p.g.) temporary hardness, 75 p.p.m. (4 g.p.g.) permanent hardness and 100 p.p.m. (6 g.p.g.) of sodium salts. Good ice should be made from such water, carefully treated, with a brine temperature of 12 deg. F. Should any particular water permit lower brine temperature, or require higher, a suitable allowance should be made.

Where designed for real submergence, the top of

ice being below the brine level at all parts of the tank, a ton of ice should be made daily for each ten cans in the tank, when 11 by 22 by 49 in. 315 lb. cans are used. This will require a high velocity of brine past the coils and cans. As the flow results from the difference in levels of the brine produced by the circulating device the degree of circulation is indicated by the difference of levels. It should be from 1 to 1½ in. for each 10 rows of cans.

Evaporator

In the past few years, great improvements have been made in the design of tank evaporators as indicated by the difference in temperature between the brine and ammonia. It is not unreasonable to expect a difference in new plants of from two to not over four degrees in this temperature difference. With 12 deg. F. brine this means an ammonia evaporating pressure of 24-lb. gage. The friction loss in the connections between evaporator and compressor should not exceed 1 lb, giving a resulting suction pressure of 23 lb.

Condenser

Of course, the condensing pressure depends on many things, as surface per ton of refrigeration, type of condenser, quantity of water and temperature of water on the condenser. Having in mind the point of view established for this discussion, namely "good practice" in plant performance, it develops that both design and operation can be checked by determining the desired discharge pressure from the temperature of the water on the condensers. The temperature of the liquid ammonia from the condenser should not be over 10 deg. F. above the temperature of the water to the condenser, and the ammonia pressure at receiver should be that found in the saturated ammonia table for this temperature. This pressure will obtain under full load conditions when the surfaces are clean and there are no foul gases in the system.

Work done in freezing a block of ice depends on the temperature of the water supply, as 70 deg. F., the size of the core, as 4 gal., and the weight of the frozen block, as 315 lb. Then, with the above conditions of evaporator and condenser and with low-pressure air supplied to cans, ice should be produced, using not over 45 kw-hr. per ton to run the compressor and auxiliaries; if the plant is of modern design and the condition favorable, this should not exceed 40. Power used by the compressor per ton of ice is proportional to the overweight of each block and the amount of refrigeration required per ton of ice, which will vary with the water and air temperatures as shown by the chart.

Quality of Ice

All plants are expected to make 98 per cent good commercial ice. This can be done when the standards for treated water for each plant are closely maintained and the necessary quantity of air is supplied to the cans (possibly as much as ¾ cu. ft. per can). A 315-lb. block requires approximately 1¼ lb. pressure at the can. The loss of pressure in the distributing system should not exceed ¾ lb., hence the pressure at the blower should be approximately 2 and not over 2¼ lb.

Operating Labor

Number of men required in a plant depends upon the amount of work to be done. The plant should be equipped with labor saving devices, as 8 or 12-can hoists, only when such equipment will actually reduce the number of men employed. The amount of labor required depends upon the size as well as the equipment used, as indicated on the following table:

Plant Capacity	Operating Labor Including day storage
25 t. per da.	1 to 1.25 man hr. per t.
50- 60 t. per da.	0.45 to 0.7 man hr. per t.
80-100 t. per da.	0.3 to 0.45 man hr. per t.

Using some such standard of comparison, anyone supervising factory operations can form a definite idea of the relative economy of the several plants as compared with known good practice. At the same time the points offering best opportunity for reducing costs are uncovered. The freezing tank may have been relatively efficient eight or ten years ago, although if measured by this year's design not enough ice is produced and too much power is required to make it. In many cases the cost of reconstructing to what is now known as efficient design has paid a large return.

New Officers Elected by United Engineering Trustees

Harry A. Kidder, superintendent of motive power of the Interborough Rapid Transit Co., New York, has been elected president for 1932 of the United Engineering Trustees, joint agency of the four Founder Engineering Societies. Mr. Kidder is chairman of the Finance Committee of the Professional Engineers' Committee on Unemployment and a fellow of the American Institute of Electrical Engineers, which he represents on the Administrative Board of the American Engineering Council.

Harold V. Coes, consulting management engineer of Ford, Bacon & Davis, and Colonel Arthur S. Dwight, president of Dwight & Lloyd Co., were named vice presidents. Dr. Alfred D. Flinn, director of the Engineering Foundation, will serve as secretary, and Clifford P. Hunt, vice president of the Chemical Bank and Trust Co., as treasurer. Other members of the board of trustees were chosen as follows:

Frank E. Winsor, chief engineer, Metropolitan District Water Supply Commission of Massachusetts, Boston; Charles A. Mead, chief engineer, Division of Bridges and Grade Crossings, Board of Public Utility Commissioners of New Jersey, Newark; Arthur S. Tuttle, consulting engineer, Board of Estimate and Apportionment, New York City; George D. Barron, mining engineer, Rye, N. Y.; R. M. Roosevelt, vice-president, Eagle-Picher Lead Co., New York; Edwards R. Fish, chief engineer, Boiler Division, Hartford Steam Boiler Inspection and Insurance Co., Hartford, Conn.; F. A. Schaff, president, Superheater Co., New York; H. P. Charlesworth, vice-president, Bell Telephone Laboratories, New York; A. W. Berresford, managing director, National Electrical Manufacturers' Association, New York.

Keen interest in their jobs netted employes of the General Electric Co. a total of $55,739 during 1931, when 19,595 suggestions were made. Of the total number of suggestions submitted 6383 had sufficient merit to be adopted. This is an average of 139 for every thousand employes.

POWER PLANT ENGINEERING March 1 1932

Operating Variables of Cyclone Dust Collectors

Research Carried Out at Brooklyn Polytechnic Institute and by the Author's Company at New Rochelle Place Cyclone Design on Scientific Basis. By Louis C. Whiton, Jr.*

UNTIL RECENT YEARS, the design and construction of cyclone dust collectors has been largely empirical and comparatively little has been published concerning the effect of the numerous variables that influence the operation of cyclones. Correlation of extensive research makes it possible to present conclusions on the following points: effect on collection of; collector diameter; collection velocity; collection temperature; mesh of dust; grain loading; arrangement of outlet pipe at the bottom of the cyclone and rate of emptying the cyclone.

Apparatus consisted of a gas-heated brick furnace, a fan, an inlet hopper for the introduction of the dust and three cyclones of the 1-ft., 2-ft. and 3-ft. diameter.

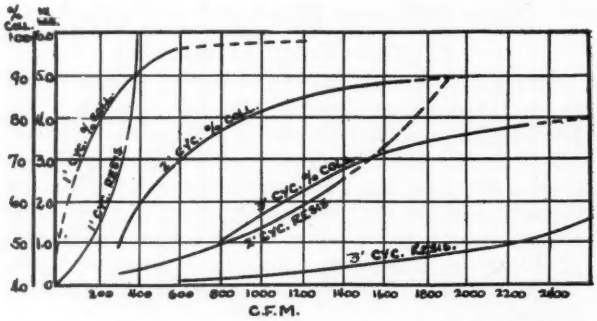


FIG. 1. COLLECTION EFFICIENCY AND RESISTANCE OF 1, 2 AND 3 FT. DIA. CYCLONES AS A FUNCTION OF THE CAPACITY

The outlets of the cyclones were connected to a straight run of pipe to the end which was connected a Canton-flannel bag. Determination of efficiency was made by introducing a known weight of dust into the system and measuring the quantity of dust caught. This was checked against the quantity of dust which escaped the cyclone collector and was caught in the cloth bag. Materials tested covered a large variety, including fly ash, Fullers earth, cement kiln dust, gray cement, and a variety of industrial products. For purposes of comparison, the fly ash from the pulverized-fuel installation was taken as the standard material in the tests. Due to the fact that it was collected by electrostatic precipitators, an average cross section as to fineness of dust produced from pulverized fuel burning was to be expected with this material.

The Effect of Diameter

Theoretically, the smaller the cyclone, the higher the collection efficiency but the higher the draft loss through the cyclone and the greater the initial cost of investment. Figure 1 shows a series of three curves indicating the capacity of cyclone and the efficiency of collection on the same material at varying draft losses with the 1, 2 and 3 ft. diameter cyclones of symmetrical design. Due to the capacity of the fan, it was not feasible to run the 3-ft. cyclone at higher draft losses than those shown but it will be noted from this curve that an optimum point is reached where the curve starts to flatten off and no important increase in collection occurred above this point.

With the 1-ft. cyclone, this optimum point is not reached until about 5.5 in. w.g. With the 2-ft. cyclone, the optimum point is reached at 2 in. w.g. The 3-ft. cyclone reaches its optimum point at approximately 1.5 in. w.g. Therefore, if for practical reasons it is assumed that the cyclone collector should operate at approximately 1.25 in. w.g. draft loss, the best collection will be obtained with the 2-ft. cyclone in preference to either the 1-ft. or the 3-ft. apparatus.

Draft loss diminishes more rapidly than the corresponding reduction of gas volume, although it does not drop as the square. With low draft loss the collection efficiency likewise drops rapidly. For example, if the 2-ft. cyclone normally operates with 1300 c.f.m. of air at 80 deg. F. it will produce a resistance of 2 in. w.g. and a collection of 86.5 per cent. If the volume should drop one-half this amount, or 650 c.f.m. the resistance drops to 0.75 in. w.g. and the collection to 72 per cent.

Fly Ash Collection

This fact would have considerable importance in the collection of fly ash from boiler flue gas, due to the fact that there is usually considerable variation in boiler rating and the collecting apparatus should be designed for maximum rating which would produce maximum dust loading in the gas and maximum gas quantity. If a boiler should vary between 300 per cent maximum and 100 per cent minimum rating, the collection would drop accordingly. Hence it would appear advantageous to control a series of small cyclones in parallel so that with half the quantity of gas, only half the cyclones would be in operation, since the overall collection will be held at its peak by maintaining the design conditions as to resistance and gas quantity per cyclone. Automatic damper control could be easily arranged to maintain constant resistance through any group of cyclones

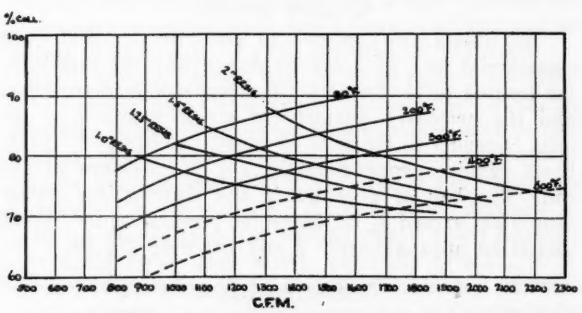


FIG. 2. COLLECTION EFFICIENCY OF 2 FT. DIA. CYCLONE AT VARIOUS RESISTANCES AND TEMPERATURES

*President Prat-Daniel Corp., New York, N. Y. From a paper presented before the Metropolitan Section of the A. S. M. E. Feb. 18, 1932.

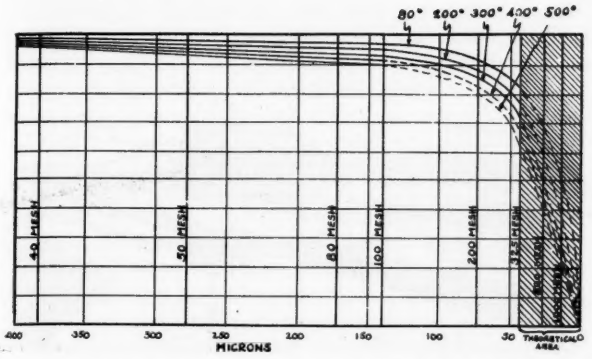


FIG. 3. COLLECTION VARIATION WITH PARTICLE SIZE AND AIR TEMPERATURE IN A 2 FT. DIA. CYCLONE HANDLING 1000 C.F.M. VERTICAL SCALE IS PER CENT DUST RECOVERY IN INCREMENTS OF 10 PER CENT FROM ZERO AT THE BOTTOM TO 100 AT THE TOP

in parallel. The above figures, it must be remembered, are on a particular pulverized-fuel dust and are of value for comparison. Fineness of dust, temperature of gas, and real specific gravity of the particles will affect the collection at different draft losses.

Effect of Temperature

It is evident that the gas from which dust particles are to be collected, may vary in temperatures from atmospheric to relatively high temperatures over 1000 deg. F. Preliminary research indicated that collection was higher with cold gas than with hot gas and this was justified by a study of Stokes law. Although the density of hot gas is less than the density of cold gas, the viscosity is considerably more, air being 1.24 greater at 212 and 1.44 greater at 392 than 32 deg. F. The results upon collection, of increasing the temperature, when using a 2-ft. cyclone, are shown in Fig. 2. From this it will be seen that the recovery efficiency drops approximately 2 per cent for each 100 deg. F. rise in temperature with a constant pressure loss. It must be remembered that the volume of gas handled through the cyclone increases as the temperature increases.

Effect of Mesh

Mechanical collectors are necessarily affected by the fineness of the dust and the overall collection can only be calculated from a knowledge of the collection that would be obtained with each specific mesh of dust. Since the finest screen which can be obtained commercially at the present time is 325 mesh, with an opening of 43 microns, all dust which will pass through this mesh

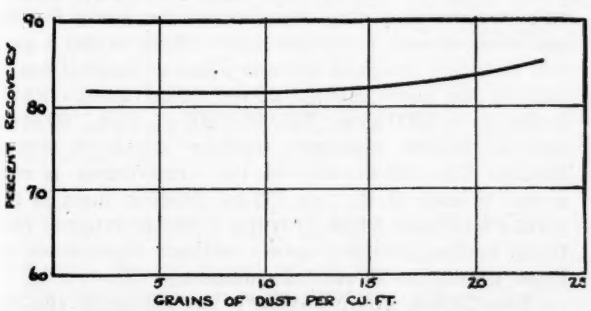


FIG. 4. RECOVERY IS ALMOST INDEPENDENT OF DUST LOADING. TESTS FROM A 2-FT. DIA. CYCLONE HANDLING 1000 C.F.M. AT 80 DEG. F.

screen is of an unknown fineness. Scientific predictions as to collection of the amount of dust, finer than 325 mesh, therefore, cannot be given. In other words, if a majority of this dust averages 10 or 15 microns (theoretically about 1000 mesh), it will have a different percentage collected than if the average is 30 or 35 microns (theoretically 400-500 mesh). Except by microscopic examination upon relatively few particles, which is inexact for the whole, there is no satisfactory way for determining precisely the average fineness of the dust passing through the finest mesh screen now obtainable.

In a series of determinations a large quantity of dust was classified and constant pressure differential and flow of air through the cyclone was maintained for the various meshes. From the large number of results obtained, the curves of Fig. 3 were devised for this particular cyclone using the pulverized fuel fly ash employed in the test. The curve is arranged according to the diameter of the particles in microns and the screen sizes given are those corresponding to the U. S. Bureau of Standards.

The curves in Fig. 3 must necessarily all reach zero collection before or at zero diameter and the dotted lines shown beyond 325 mesh or 43 microns are estimations only; however, it serves to give some idea of the expected collection of 27-micron material (theoretically 500 mesh) and 13.6-micron material (theoretically 1000 mesh). In the former case, this would appear approximately 70 per cent collection at 80 deg. F and in the latter case 50 per cent collection. As a matter of comparison, it might be of interest to remark that red blood corpuscles are seven microns in diameter and that, according to Stokes law, a 13.6-micron particle (considered as spherical and of silica) will float 13.8 mi. in a 10-mi. breeze from a 200-ft. height before reaching the ground. By this curve an exact prediction can be given for dust larger than 325 mesh if the granularmetric analysis is obtainable beforehand concerning the collection of similar dust in a similar cyclone.

Effect of Grain Loading

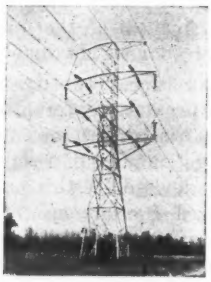
Theoretically the concentration of the dust in the gas should have no effect upon the percentage collection due to the fact that each grain of dust is acted upon independently by the forces exerted upon it. The curve in Fig. 4 indicates that within the usual limits of grain loading ranging from 1 to 22 per cu. ft. there is practically no difference as was to be expected.

Various shapes were designed for the outlet pipe which carried the dust away from the cyclone. It was found that an increase in diameter of the pipe at the outlet of the cyclone had an advantage over a straight pipe and acted somewhat in the nature of the check-valve preventing the dust at the bottom of the vortex, formed inside of the cyclone, from being drawn back with the current of air.

Effect of rapid emptying of the cyclone is closely related to the above observations. It was found that if 6.875 lb. of dust were allowed to remain in the 3-ft. cyclone, when operating at 1.2 in w.g. draft loss, handling 2450 c.f.m. there was a loss of 0.314 per cent per minute. It is evident that it is an advantage to evacuate as much of the dust as possible, as rapidly as possible, from the bottom of the cyclone by means of proper containers and a properly designed outlet pipe.

POWER PLANT ENGINEERING March 1 1932

Electrical Features of Harding Street Station



HARDING ST. STATION of the Indianapolis Power & Light Co. adds 70,000 kw. of generating capacity to the company's system at Indianapolis, Ind. This is a 450-lb., 725 deg. F. station with eight 11,810-sq. ft. stoker fired Springfield boilers with water walls, economizer and air heaters and two 35,000-kw. Westinghouse generating units. A description of the mechanical features with heat balances and a list of equipment appeared on page 153 of the Feb. 15 issue of Power Plant Engineering. This station supplies Indianapolis through a new 50-mi., 132-kv., loop around the city, feeding the 12 present district substations through four new high tension substations operated by supervisory control from Morris St. substation. Three older stations, Kentucky Ave., Mill St. and Washington Ave., generate at 4000 v. and are connected to the new station only through the 4000 and 33,000-v. systems.

Generating station, transmission lines and substations (including the switchyard steel structure) were designed and constructed by the Management & Engineering Corp., Chicago, Ill.

In the new station each of the two main units consist of a 43,750-kv-a., 0.80 p.f., 13,800-v. 3-ph., 60-cycle turbine driven generator star connected with the neutrals grounded through a 3-ohm reactor, each neutral being provided with a Westinghouse Type B-13 single-pole 15,000-v. solenoid operated oil circuit breaker with necessary disconnect and supporting structures mounted below generator foundations on basement floor.

On the same shaft with each main unit and designed for parallel operation with the unit is a 2185 kv-a., 3-ph., 60-cycle, 2300-v. auxiliary house generator, provided with its own direct driven 20-kw., 125-v. shunt wound exciter. This house generator is provided with a small motor operated field rheostat which is controlled from the main switchboard panel.

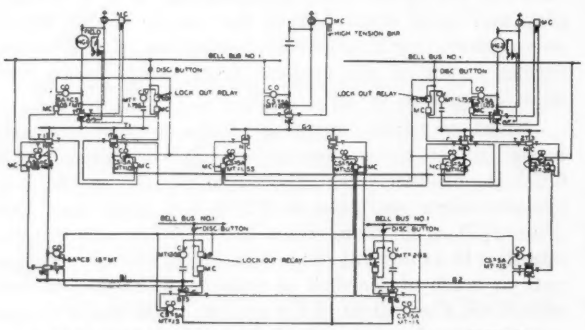


FIG. 2. SCHEMATIC VOLTAGE CHASER SCHEME

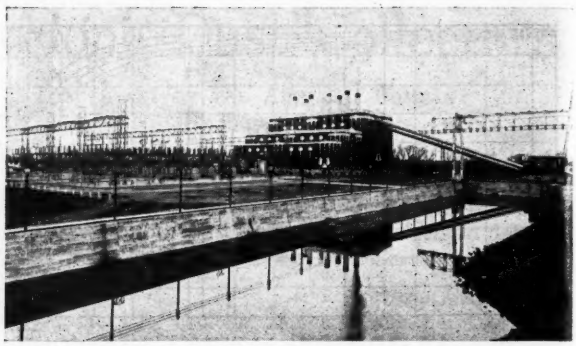


FIG. 1. GENERAL VIEW OF STATION WITH SWITCHYARD AT THE LEFT

Each main unit is provided with a Westinghouse 175-kw., 250-v. motor driven exciter which in turn is provided with a small pilot exciter, the shunt field of which is provided with a rheostat control on the main switchboard panel, thus eliminating the use of a main generator field rheostat. An emergency dual drive 175-kw., 2500-v. exciter can be used with either unit.

Main Station Connections

A bank of three Westinghouse 14,583-kv-a. single-phase 13,800/132,000-v. outdoor type oil insulated self-cooled power transformers are directly connected to each generating unit. These 13,800-v. connections are carried through under ground and are arranged from delta on the low side to star on the high side, each 13,800-v. delta connection being made of two 3,000,000-c.m. lead covered cambric insulated cables.

Metering is taken care of from instrument transformers located on the generator side of the transformer bank. Current transformers are also inserted in such a manner that differential protection is provided around both generator and transformer. Since the generator switching is done on the 132-kv. side, each generating unit is provided with a Westinghouse Type G-22-P, 132,000-v. 3-pole separate tank outdoor type oil circuit breaker which is equipped with Deion grid contacts and also with potential devices for 132 kv. synchronizing.

Auxiliary Station Connections

Each main operating unit is provided with its individual 2300-v. auxiliary bus which carries all oil circuit breakers supplying the essential auxiliaries for the operation of each particular unit. There is also a general auxiliary bus with necessary bus tie connections to each of the above mentioned individual groups which is fed by a 2500-kv-a., 132,000/2300-v., 3-ph., 60-cycle outdoor station auxiliary outdoor step-down transformer. The 132-kv. side of this transformer is connected to each of the two 132-kv. outdoor buses in the plant switchyard which provides a double external feed to all station auxiliary power without dependence on house generators in case of emergency.

This 2300-v. group auxiliary bus scheme is also extended to the boiler room and provides two separate buses, each of which carries the complete auxiliary

equipment for four of the eight boilers installed in the plant. There is, therefore, installed a total of five 2300-v. auxiliary group buses which are tied together with a voltage chaser scheme of operation which is illustrated in the diagram Fig. 2 and which in case of a fault occurring in any one of these buses will eliminate the occurrence of interruptions on any of the other groups.

In case of failure of the main unit, which in turn would affect its respective house unit, the auxiliaries for this main unit will be automatically taken care of through voltage chaser connections between the general auxiliary group and that particular main unit group upon which the house turbine has failed. This will keep all essential auxiliaries, such as circulating pumps and condensate pumps, operative in such a manner that the main unit which failed may be restored to service as quickly as possible.

A careful study of the above mentioned diagram will serve to illustrate the many possibilities provided for the continuous operation of auxiliary equipment in this plant. Sequence of operation for 10 different faults is given in the accompanying table.

In the main control room of the plant, Fig. 3, are installed three separate switchboards consisting of one benchboard section for main generator and house generator controls, one high line switchboard for 132-kv. switch yard control and one board for the hand control of the various station auxiliary 2300-v. group buses.

Practically all of the remote control equipment in the plant is operated from a 125-v. direct current main supply bus which takes care of all circuit breakers operating in the switch house, all of the large G-22-P circuit breakers in the switch yard and also distributes power to an additional 125-v. group bus in the boiler room which takes care of the remote control operation of various types of motor starters, oil circuit breakers and other gage board d.c. supply circuits. This 125-v. main d.c. bus is fed by a 660-amp-hr. storage battery. The main d.c. control board, 10-kw. motor generator charging set and battery are installed in a separate room.

Station Auxiliary Equipment

Since the company has adopted the standard practice of 440-v. operation for all motors under 50 hp., except in special cases, the station is provided with five 460-v. group buses which are supplied through step-down transformers from the five 2300-v. auxiliary group buses. These 460-v. bus sections are of the steel cubicle type. A rather unique feature in connection with these bus sections is the fact that the step-down transformers are included in the same structure with the Multumite breakers, one being placed at each end of the bus. Each one of the 440-v. buses has two feeds from each 2300-v. bus group.

Steel structure for the mounting of the 132-kv. equipment assembly covers an area of 250 by 270 ft., the structure itself being of the latticed tower design built to accommodate a 132-kv. double bus double breaker scheme of operation. The structure for the present constitutes seven complete bays for the accommodation of

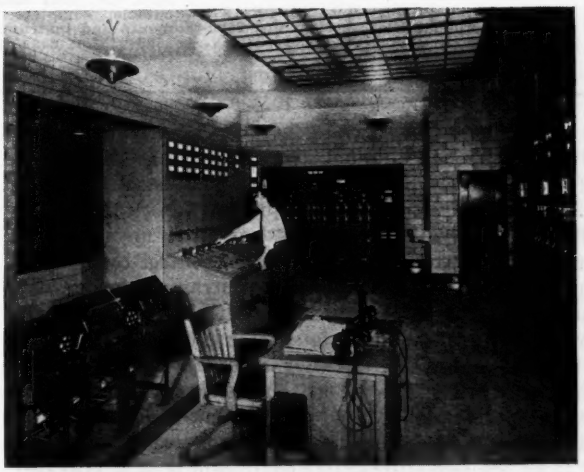


FIG. 3. CONTROL ROOM OF THE NEW STATION

Details of Voltage Chaser Scheme

SEQUENCE OF RELAY OPERATION—2300-V. STATION AUX. BUSES

1. Fault in auxiliary transformer or feeder to general bus. Differential relays will open breaker G1. Then after all motors have been disconnected from that bus, operator can close in on one of the turbine buses for lighting service.
2. Fault on general auxiliary bus. CO relays at breaker G1 will open that breaker and ring an alarm. Operator should then open breakers G3 and G11 to disconnect bus entirely, till repaired. Now assume that general auxiliary bus is in service and will stay O.K.

VOLTAGE CHASER SCHEME

FAULT NO. 1. Loss of voltage on turbine buses through fault in house generator field circuit. Low voltage relays on that particular bus will open breaker 1T1 or 2T1 respectively and close 1T8 or 2T2 and at the same time ring an alarm to tell operator that something has happened. Service can continue till repair is made or spare unit is in service.

FAULT NO. 2. Fault in house generator or its feeder to the turbine auxiliary bus. Differential relays will open breaker 1T1 or 2T1 and also the field breaker. Bus will be dead and the low voltage relays will close breaker 1T8 or 2T2 respectively. Service can continue as in case No. 1.

FAULT NO. 3. Fault in turbine bus when feeding from house generator. CO relays at breaker 1T1 or 2T1, respectively, will open breaker 1T1 and 1T7 or 2T1 and 2T2 respectively and also lock out the corresponding low voltage relays so that the bus cannot be automatically connected to the general auxiliary bus. Spare unit must be put into service.

FAULT NO. 4. Fault on turbine bus when house generator is out of service and bus is connected to general auxiliary bus. CO relays at 1T8 or 2T2 respectively will open breakers 1T7 and 1T8 or 2T2 and 2T3 respectively and at the same time lock out corresponding low voltage relays, so that bus cannot be automatically reconnected to general auxiliary bus again. Spare unit must be put into service.

NOTE. When relays have operated for faults No. 3 or 4 the boiler room bus that was connected to the turbine bus in question will lose its voltage but the low voltage relays on that bus will close in on the general auxiliary bus and boilers can be operated as before.

FAULT NO. 5. Fault on feeder to turbine bus Nos. 1 and 2 from general auxiliary bus G. CO relays at breaker G3 will trip breakers G3-1T8 and 2T2 and at the same time lock out low voltage relays on both turbine buses so that buses cannot automatically be closed in on faulty feeder.

FAULT NO. 6. Fault on feeder between bus T1 and B1 or T2 and B2. CO relays at 1T7 or 2T3 respectively will trip breakers 1T7 and B1 or 2T3 and B2 respectively. The low voltage relays on corresponding bus will then close breaker B15 or B16 respectively and service can continue as before.

FAULT NO. 7. Fault on feeder to boiler room buses B1 and B2 from general auxiliary bus G. CO relays at breaker G11 will trip breakers G11, B15 and B16 and at the same time lock out low voltage relays on both boiler room buses so that buses cannot automatically be closed in on faulty feeder.

FAULT NO. 8. Fault on boiler room bus B1 or B2 when they are connected to T1 or T2. CO relays at breaker B1 or B2 will trip breaker B1 or B2 respectively and at the same time lock out the corresponding low voltage relays so that bus cannot automatically be closed in on general auxiliary bus G. Other boiler group must be put into service.

FAULT NO. 9. Fault on boiler room bus B1 or B2 when fed from general auxiliary bus G. CO relays at breaker B15 or B16 respectively will trip breakers B15 or B16 respectively and lock out corresponding low voltage relays so that bus cannot automatically be closed in on general auxiliary bus G again.

FAULT NO. 10. Loss of voltage on either boiler room buses B1 or B2 without fault on either feeder or on bus. Low voltage relays will trip breakers B1 or B2 respectively and then close in on general auxiliary bus G.

Harding St. Electrical Equipment

MAIN GENERATORS, 2, Westinghouse Elec. & Mfg. Co., 43,750-kv-a., 0.80-p.f., 3-ph., 60-cycle, 13,800-v., 1800-r.p.m., star connected generator with neutrals grounded through a reactance. No oil circuit breakers on the 13,800-v. side, main leads pass direct to

MAIN TRANSFORMERS, 2 banks, Westinghouse Elec. & Mfg. Co., outdoor type OISC, single-phase, 14,583-kv-a., 13,800/132,000-v.

HOUSE GENERATORS, 2, Westinghouse Elec. & Mfg. Co., 2185-kv-a., 0.80-p.f., 2400-v., 3-phase direct driven star connected with non-grounded neutral. Excited by 20-kw., 125-v., direct connected exciters.

MAIN EXCITERS, 2, Westinghouse Elec. & Mfg. Co., 175-kw., 250-v. motor generator sets with 1½-kv., 250-v. pilot exciters. Driven by a 265-hp., 2300-v., 1180-r.p.m. line start induction motor. Arranged for possible future rheostatic voltage regulation.

EMERGENCY EXCITER, 1, Westinghouse Elec. & Mfg. Co., 175-kw., 250-v., generator set with 1½-kw., 250-v. pilot exciter. Dual driven by a 265-hp., 2300-v. motor and a 265-hp. noncondensing turbine.

AUXILIARY POWER TRANSFORMER, 1, Westinghouse Elec. & Mfg. Co., 2500-kv-a., outdoor type OISC 132,000/2300-v., 3-ph. transformers.

AUXILIARY TRANSFORMERS, 11, Westinghouse Elec. & Mfg. Co., 2300/-460/230-v. type OISC. Eight of 150-kv-a. and three of 300-kv-a. capacity.

CONTROL SWITCHBOARD, 1, Westinghouse Electric & Mfg. Co. complete control switchboard of main generator bench section and two vertical hinged type cubicle sections for 2300-v. auxiliary and 132-kv. high line control.

AUXILIARY SWITCH GEAR, 5 groups, Condit Elec. Mfg. Co., 2300-v. track type, metal clad type D-12 with oil circuit breakers on removable unit and complete with current transformer, automatic disconnects and bus section housings.

CUBICLES, 5 groups, I-T-E Circuit Breaker Co., Multumite steel cubicle switch mounting for 460 v.

MAIN BREAKERS, 14, Westinghouse Electric & Mfg. Co. type G-22-P. 132-kv. outdoor solenoid operated breakers.

OIL CIRCUIT BREAKERS, 22 pairs, Delta Star Elec. Co., type CIE solenoid operated mechanically and electrically interlocked for 2300-v. forced and induced draft fan, ash sluice pump and deep well pump circuits.

BREAKER CUBICLES, 1, Delta Star Elec. Co., four unit oil circuit breaker cubicle, complete with panel, instruments and instrument transformers for 2300-v. for coal handling and gantry crane circuits.

MOTOR STARTING CONTACTORS, 42, Cutler-Hammer, Inc., contactors on all 460-v. small motor contacts.

SUBSTATION STRUCTURE, 1, 132-kv. with structural work by Mississippi Valley Steel Co. Railway & Industrial Eng. Co. disconnecting switches, bus supports and connections.

SWITCHBOARDS, 2, Starrett Mfg. Co., metal clad 125-v. d.c. equipped with complete bus bar connections, General Elec. Co., type 13k-2 switches and 2 pole I-T-E Circuit Breaker Co., senior circuit breakers.

STORAGE BATTERY, 1, Philadelphia Storage Battery Co., type F P.G., 660-amp-hr., floating on one 10-kw. diverter pole motor generator charging set.

LIGHTING CABINETS, 6, Starrett Mfg. Co., complete with fuses and bus connections.

RESISTOR, 1, Westinghouse Elec. & Mfg. Co., 50-ohm, 73-kw., neutral ground resistor with 73-kv. auto valve lightning arrestor mounted directly on bushing.

OIL PLANT, 1, complete filtration plant with S. F. Bowser & Co. pumps, Sharples Specialty Co. filters and two Graver Tank Co., 10,000-gal. tanks.

FIRE PROTECTION, Waller Kidde & Co., Lux system of CO_2 fire protection on main and house generators.

CABLES, 3,000,000-c.m. Okonite Cable Co. lead covered, cambric insulated.

three outgoing lines, two generator bays, one auxiliary transformer bay and one bay which serves as a tie line to the Lenore Substation of the Indiana Electric Co. All of the above circuits are equipped with two Westinghouse type G-22-P 132-kv. outdoor oil circuits breakers, remotely controlled from the main control room in the plant. The 132-kv. transformer neutral is provided with a 50-ohm outdoor type 73-kv. neutral current limiting reactor which has the unique feature of having a 73-kv. auto valve lighting arrester mounted directly on its bushing. All of the 132-kv. bus work consists of strain type construction using 350,000-c.m. stranded copper, tube wire guides being used where necessary. All of the 132-kv. disconnecting switch equipment is hand operated.

In order to cut down costs, no 132-kv. bus potential transformers have been installed, all 132-kv. bus potential being supplied through potential devices installed in the bushings of the oil circuit breakers and having sufficient volt-ampere capacity to be used for synchronizing purposes. All of the 132-kv. oil circuit breakers are provided with Deion grid elements and are solenoid operated.

There has been a very complete transformer and oil circuit breaker oil piping system installed in this switch yard which makes it possible to filter any individual to protect the cables at the point where they emerge piece of apparatus separately, there having been provided two 10,000 gal. oil storage tanks, one for clean oil and one for dirty oil and connected in such a manner that with the aid of a high capacity Bowser pump and transformer or oil circuit breaker may be emptied and refilled with clean oil in the shortest possible time.

The 132-kv. oil circuit breakers are solenoid operated at 125 v. direct current, the switch yard being fed by four 250,000-c.m. d.c. control circuits, each of which terminates in an outdoor weatherproof steel enclosed control box, each box being provided with branch lines for the control of four circuit breakers.

Each of the 14,583-kv-a. single-phase outdoor transformers are provided in their low tension side with cable entrance boxes in such a manner that the 3,000,000-c.m. lead covered cables coming from the main generating units are connected to the low tension transformer bushings which project into these entrance boxes which forms a very complete weather-tight connection and is so arranged that cables may be easily disconnected to allow for removal of transformers as the above mentioned cable connections are brought up on the opposite side from the transformer transfer track.

This cable connecting scheme is protected by the use of wire guards on steel frame work which serves from the ground and pass up to the transformer terminal box. These wire guards are also removable to give access for the disconnecting of the cables.

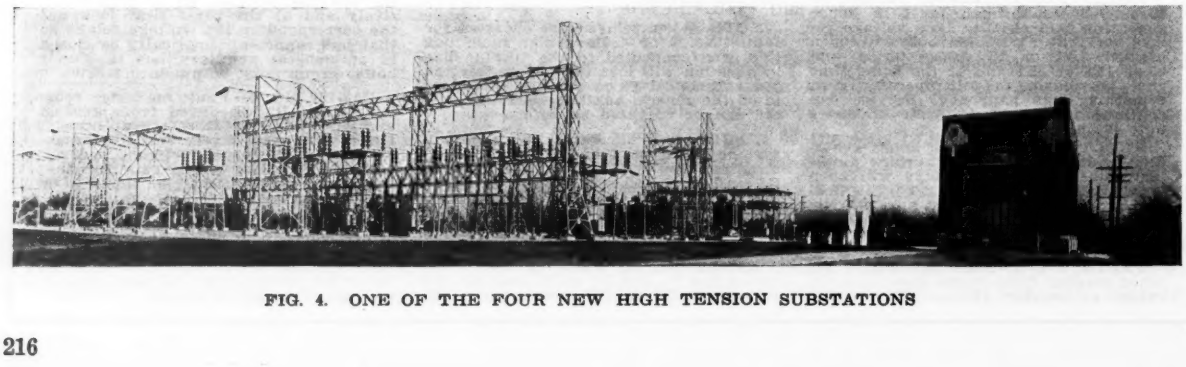
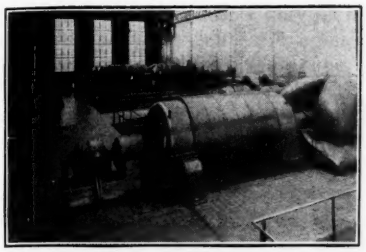


FIG. 4. ONE OF THE FOUR NEW HIGH TENSION SUBSTATIONS



PARALLEL OPERATION OF A. C. GENERATORS

By E. H. STIVENDER

Part IV.* Indicating synchronism by means of incandescent lamps. Paralleling single phase machines. Phasing out polyphase machines. Checking phase rotation. Abnormal voltage conditions possible in some circuits

IN PARALLELING alternating current generators the difficulties are somewhat greater than with direct current machines. It is not only necessary to bring the voltages to the same value but they must be of the same frequency and in phase, hence the term "synchronizing" has to a great extent replaced "paralleling" in the parlance of the electrical industry, when alternating currents are discussed.

The earliest method by which synchronism was indicated commercially is probably the lamp method; it is still much used as an accessory to the synchronism indicator, or "synchroscope". Figure 1 shows a sketch which is identical with the usual method of indicating the proper polarity between two direct current generators before paralleling. In the case of 110-v. alternators and lamps of equal resistance, the voltage across either of the lamps varies periodically between 110 volts and zero, being zero when the proper phase relation exists. Owing to the chance of one of the lamps burning out at the critical moment, giving a false indication, the lamps are sometimes connected diagonally across the line switch as shown by the dotted connection of Fig. 1. In this case, synchronism is indicated when the lamps are at greatest brilliancy.

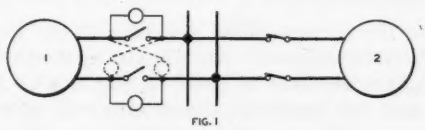
As voltages are increased, the use of instrument transformers in connection with synchronizing lamps becomes necessary.

Since lamps, especially carbon filament types, become dark some time before the voltage has reached zero, voltmeters have in some cases been substituted. With this, certain complications have been introduced owing to ordinary a.c. instruments being inaccurate on the lower part of the scale. In order to offset the effect of this, a scheme of replacing the usual series resistor of the voltmeter with a high positive coefficient resistor has been tried, thereby causing the variations to be more gradual as the voltage approaches zero.

Due to the negative resistance coefficient of carbon filament lamps are preferable for bright lamp synchronizing, since voltage changes on the high part of the curve are more easily detected. The hot resistance is about half the cold resistance. Likewise, with dark lamp synchronizing, as is most generally used in the United States, tungsten filament lamps are more desirable. The resistance of tungsten when hot is about 10 to 13 times that when cold. Ordinarily it might be supposed that changes in resistance will cause the brilliancy to vary in direct proportion but since the heat generated in a conductor varies as the square of the current, the brilliance will change much greater than in direct proportion to the current.

Checking of Phase Sequence

A usual method of checking like phase sequence of two-phase systems is shown in Fig. 2, four transformers are used. If the proper phase relation exists the lamps will become bright and dark together, if other than the proper relations are present the lamps will become alternately bright and dark, or will increase and decrease in brilliancy without becoming completely dark. Proper connections for phasing out three-phase generators are illustrated in Fig. 3. If the proper relations exist, the lamps will become bright and dark together, otherwise alternate bright and dark periods will occur, all lamps in either case becoming totally dark at intervals, owing to the line voltages of three-phase systems being equal,



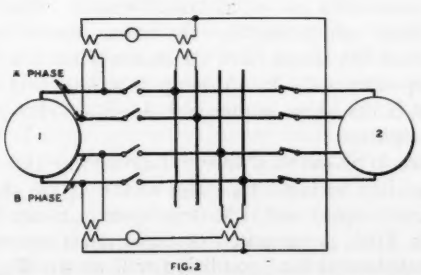


FIG. 1. THE LAMP METHOD OF SYNCHRONIZING SINGLE PHASE GENERATORS

FIG. 2. METHOD OF PHASING OUT TWO-PHASE FOUR-WIRE GENERATORS

*Parts I, II and III appeared in the October 15, December 1, 1931 and February 1, 1932 issues respectively.

while in two-phase, one or two voltages are approximately 41 per cent higher than the others.

Some form of marking is usually provided by the manufacturer, either on drawings furnished or by marking the leads, directly, or both; however, it is always safer as a final check to phase out electrically by one of the several different methods in order to prevent possible disastrous results.

In certain cases, the proper equipment is not available when a generator must be placed on the line for the first time. By examination of the winding, it can in many cases be readily determined what the phase

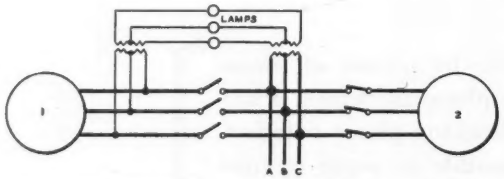


FIG. 3. CONNECTIONS FOR PHASING OUT 3-PHASE, 3-WIRE MACHINES

sequence will be. In Fig. 4 is shown a diagram of the connection end of a 6-pole, three-phase, three-circuit, full pitch distributed winding. By the markings of the terminals shown, the rotation of the field poles must be from right to left in order to give the sequence 1, 2, 3 from right to left. If the rotation of the field poles is from left to right the phase sequence is 3, 2, 1.

Not only does it occur that the phase sequence of the generator must be known but that of the line must be obtained, since in many cases the supposed sequence of the line may be opposite to the actual sequence, hence

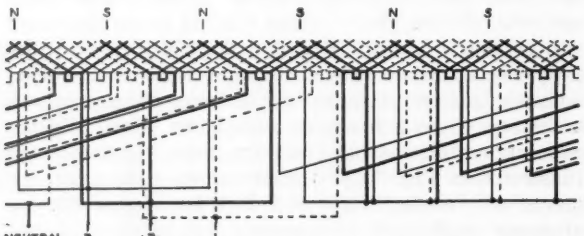


FIG. 4. THE PHASE SEQUENCE OF A MACHINE MAY BE PRE-DETERMINED WHERE IT IS POSSIBLE TO EXAMINE THE WINDINGS

obtaining the correct phase sequence of the generator is generally inadequate. An efficient method of determining phase sequence is given in Fig. 5(a). A small reactor and two lamps are connected to the secondaries of two open-delta potential transformers. The reactor should have approximately the same ohmic value of reactance as the lamps have resistance when hot. If the phase sequence is C—B—A, lamp B will be bright while A is dim, if the phase sequence is A—B—C, lamp A will be the brightest.

Figure 5(b) shows a vector diagram for this circuit. The three line voltages E_{AB}, E_{BC} and E_{CA}, are shown by heavy lines, equal and 120 deg. apart. Since the circuit, Fig. 5(a), is composed of three parts connected in Y, an unbalanced load condition will exist. E_{AB} is the sum of the two components $-E_{OA} + E_{OB}$, E_{BC} equals $-E_{OB} + E_{OC}$, and E_{CA} equals $-E_{OC} + E_{OA}$. E_{OA}, the voltage across lamp A, is approximately 23.2 per cent

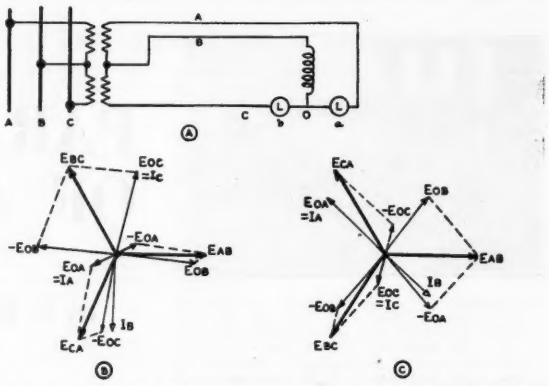


FIG. 5. (a) A CONNECTION WHEREBY PHASE SEQUENCE MAY BE DETERMINED BY MEANS OF A SMALL REACTOR AND LAMPS. (b) VOLTAGE RELATIONS PRESENT FOR A PHASE ROTATION OF C-B-A. (c) VOLTAGE RELATIONS WHERE PHASE ROTATION IS A-B-C

of line voltage; E_{OB}, the voltage across the reactor, is approximately 77.5 per cent, and E_{OC}, the voltage across lamp B, is 86.6 per cent of line voltage, approximately. To check, $I_B + I_C = I_A$, E_{OB} leads I_B by 90 deg., I_A and I_B are in phase with E_{OA} and E_{OB} respectively. Figure 5(c) illustrates the voltage relations when the phase rotation is A—B—C.

Since tungsten has an exceptionally high temperature coefficient, the voltages across different parts of the circuit will show deviations from those given but since the current of lamp B is normally about 3.7 times greater than that of lamp A, the phase sequence can readily be checked even though a voltage error may exist.

As has been suggested before, since there is always a chance of error when too many different connections are used in the process of phasing out, it is much more satisfactory to obtain the transformers and apparatus required for a direct check when such are not available among the permanent equipment.

Nearly all power stations are arranged so that no temporary connections are required in order properly to phase out a machine. Figures 6(a) and 6(b) are general diagrams of conventional layouts in small and large power stations. In Fig. 6(a) the auxiliary motors are supplied from the bus and the arrangement is such that either the generator or line may supply the power needed. Since only phase sequence, or phase "rotation", is in question, if an auxiliary motor rotates in the same direction when fed from generator or line, the phase sequence is the same and the generator may be brought to synchronism as indicated by the synchroscope and lamps and paralleled. To check the synchroscope

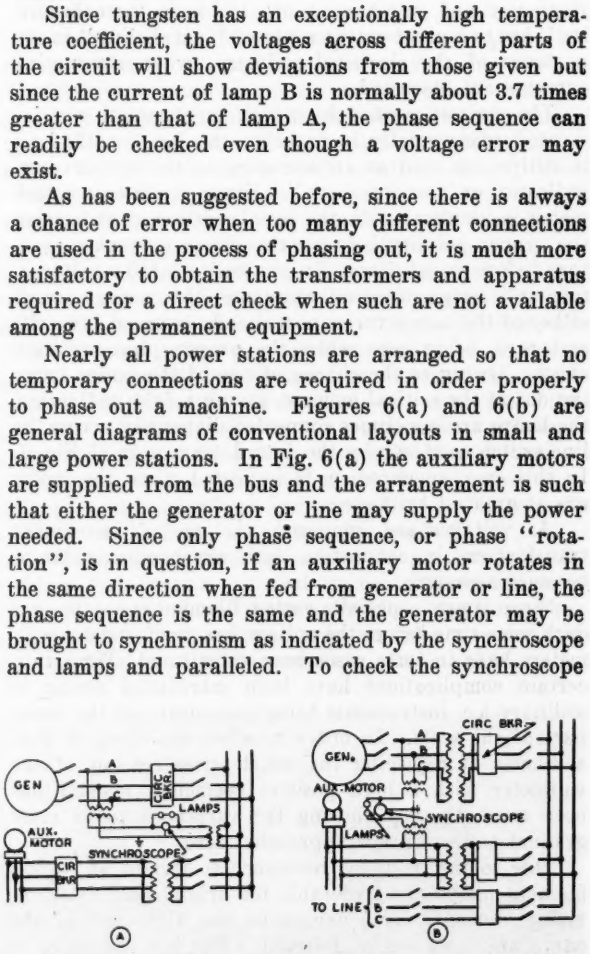


FIG. 6. (a) TYPICAL POWER STATION LAYOUT, INDICATING THE CONNECTIONS USED FOR SYNCHRONIZING. (b) STATION DIAGRAM WHERE ALL SYNCHRONIZING IS DONE FROM LOW TENSION POTENTIAL TRANSFORMERS

for proper connections, either the line circuit breaker and generator circuit breaker may be closed, leaving the disconnects next the generator open, or the generator circuit breaker and disconnects may be closed, leaving the line circuit breaker open. The lamps should be dark and the synchroscope indicate synchronism, when the connections are correct. The above procedure will give positive indications of the proper phase relations between generator and line. If the motor runs in opposite directions, changing any two leads of the generator or line will establish the correct relations.

Due to occasional objections to the above systems of phasing out, a scheme such as in Fig. 7 is sometimes employed. It, however, has been known to cause the introduction of destructively high voltages in the generator windings. The indications of the lamps are similar to those in Fig. 3; the maximum voltage attained will be $2/\sqrt{3}$, or about 1.15 times line voltage (divided by the transformer ratio). This is evidenced by the

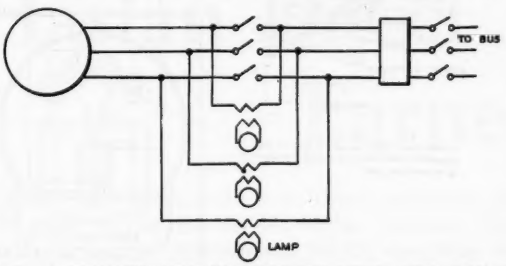


FIG. 7. A CONNECTION SOMETIMES USED FOR PHASING OUT THREE-PHASE GENERATORS. IT POSSESSES CERTAIN UNDESIRABLE FEATURES

fact that since the transformers are in series with the line, their connection assimilates the Y connection, hence when the generator voltage is 180 deg. from the line voltage the two voltages across one transformer are in series and are added; therefore, if potential transformers designed to operate at line voltage are used, little danger can occur due to saturation causing rapid changes in flux density, because saturation of the potential transformer core should never be reached. The mistake must not be made, however, of using transformers intended for use on circuits of half the normal line voltages present as may occur due to the similarity to the Y connection, because there is great danger of high induced voltages due to saturation of the potential transformer core, even though the transformer insulation may stand the added stresses and heating.

There is another condition which may cause the existence of abnormal voltages which will not necessarily be attributed to saturation. It is the case of reactance in series with capacitance causing a resonant or partially resonant condition which may possibly cause the voltage to reach near infinity. The effect of the generator insulation is to act as dielectric between the conductors and ground, if a grounded neutral is not used and one line wire should be grounded, hence forming a condenser—after a fashion. If the ohmic value of the generator capacity reactance equals the ohmic value of the potential transformer reactance, a resonant condition will exist, should a lamp burn out.

Editor's note: Attention is directed to an error in Part I of this series of articles on page 1023 of the October 15, 1931, issue In the second paragraph from the bottom, column two, the sentence reading: "they cannot be overloaded, since excitation depends upon line voltage" should be changed to read "they cannot be overloaded due to short circuits on the connecting transmission line since the excitation depends upon the line voltage."

Remote Reading of Watthour Meters

Meter Readings May Be Observed Over Subscribers' Telephone Lines

REMOTE READING OF electric meters in residences is not feasible by any of the several telemetering schemes so far developed on account of the amount and nature of special apparatus required at the meters being read. For this reason a scheme worked out in the General Electric Laboratory and described by A. S. Fitzgerald in a recent number of Electrical Engineering is of interest. With this system the bulk of the apparatus is concentrated at the power company's premises, a simple electromechanical device being the only apparatus installed at the meter itself.

This scheme it must be understood is not commercially available and its practical application of course would depend upon the agreement possible between the telephone company and the power company so as to permit the necessary interconnection of power and communication. The system is interesting, however, and presents an idea which might be useful in other fields than the one for which it was devised and so we are presenting it here.

In this proposed arrangement, connection between the power company's "observing" apparatus and the consumer's meter is made by means of telephone lines, the connection being made through the power company's connection with the telephone central exchange, thence to the consumer's residence over the telephone company's regular subscriber's circuit. As already mentioned, before this could be done arrangements would have to be made between the telephone and power company.

Any system of remote reading quite obviously must justify itself from a cost standpoint. Average cost for reading a meter in a city district has been estimated at from 1.5 to 2.0 cents, and from 10 to 15 cents in a rural district. On the basis of these estimates, the maximum justifiable investment for remote reading equipment is $4 for city and $30 for rural districts. An additional expense item would be involved in the use of the telephone company's lines. Also the fact that the plan postulates that each consumer is a telephone subscriber must be taken into consideration.

The general arrangement of equipment, together with the scheme of operation are indicated in Fig. 1, while in Fig. 2 may be seen a standard watthour meter rigged up for experimental purposes. The four tuning dials of the audio generator in the power company's office are arranged so as to indicate directly the positions of the four meter hands. Thus, after all four dials of the generator have been adjusted to "find" the positions of their respective meter hands, these tuning dials directly represent the watthour meter reading.

Several difficulties were experienced during the course of the experiments. One of the chief of these concerned the vacuum tube audio generator. Most of these difficulties were overcome, however, with the installation of a more stable and precise unit, and the provision of means for checking its accuracy. Variation in the frequency of response of the reeds due to wearing of the

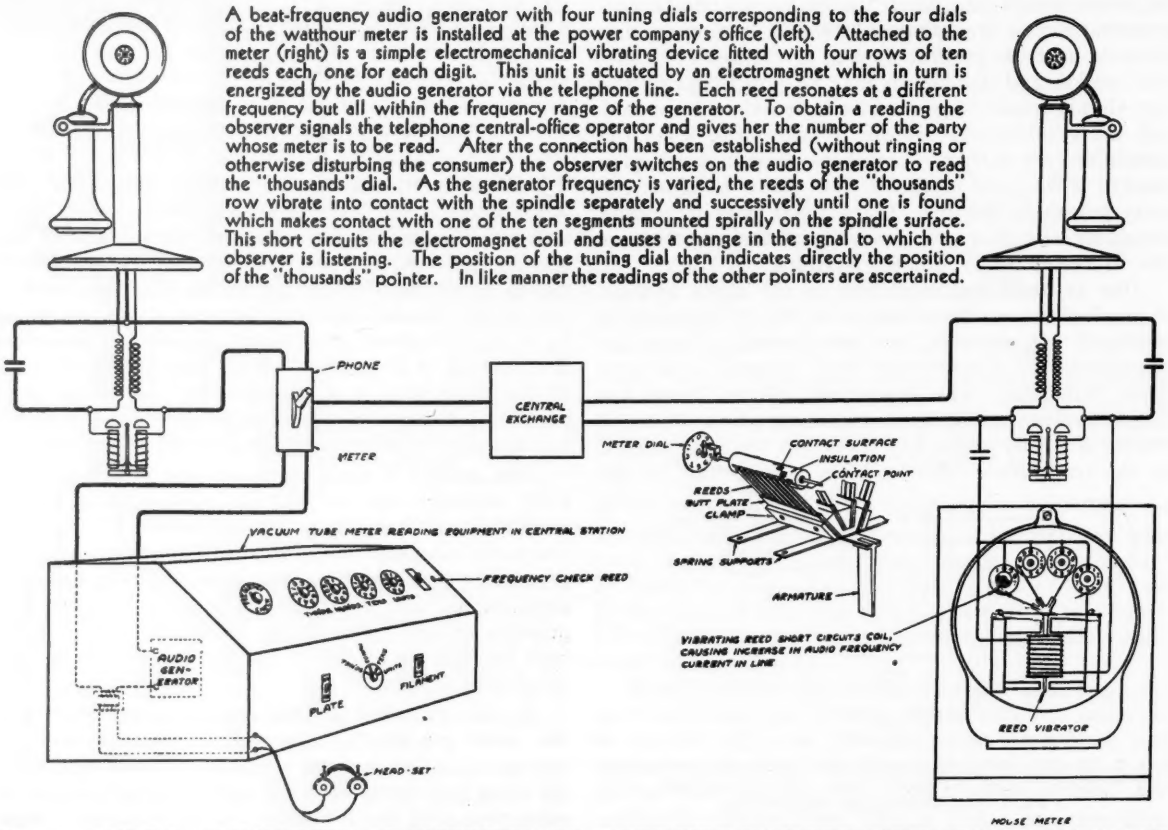

A beat-frequency audio generator with four tuning dials corresponding to the four dials of the watthour meter is installed at the power company's office (left). Attached to the meter (right) is a simple electromechanical vibrating device fitted with four rows of ten reeds each, one for each digit. This unit is actuated by an electromagnet which in turn is energized by the audio generator via the telephone line. Each reed resonates at a different frequency but all within the frequency range of the generator. To obtain a reading the observer signals the telephone central-office operator and gives her the number of the party whose meter is to be read. After the connection has been established (without ringing or otherwise disturbing the consumer) the observer switches on the audio generator to read the "thousands" dial. As the generator frequency is varied, the reeds of the "thousands" row vibrate into contact with the spindle separately and successively until one is found which makes contact with one of the ten segments mounted spirally on the spindle surface. This short circuits the electromagnet coil and causes a change in the signal to which the observer is listening. The position of the tuning dial then indicates directly the position of the "thousands" pointer. In like manner the readings of the other pointers are ascertained.
PHONE
METER
CENTRAL EXCHANGE
METER DIAL
CONTACT SURFACE
INSULATION
CONTACT POINT
REEDS
SPRING SUPPORTS
ARMATURE
VACUUM TUBE METER READING EQUIPMENT IN CENTRAL STATION
FREQUENCY CHECK REED
AUDIO GENERATOR
PLATE
FILAMENT
HEAD-SET
VIBRATING REED SHORT CIRCUITS COIL, CAUSING INCREASE IN AUDIO FREQUENCY CURRENT IN LINE
REED VIBRATOR
HOUSE METER

FIG. 1. GENERAL ARRANGEMENT OF EQUIPMENT FOR "OBSERVING" WATTHOUR METER READINGS OVER REGULAR SUBSCRIBERS' TELEPHONE CIRCUITS

contact tips or temperature differences was found to be negligible; however, serious difficulties would be experienced in carrying out the scheme where party telephone lines are in use, or where machine switching exchanges are employed. Additional equipment no doubt would be required under these conditions. The equipment and circuits described in this arrangement are mentioned merely as a suggestion of a future possibility. Engineering phases of the problem have been proved by extensive laboratory experiments to be capable of relatively simple solution, but of course the commercial application is quite another question and naturally would hinge principally upon the inter-company agreements that would be necessary before established communication channels could be put to such use.

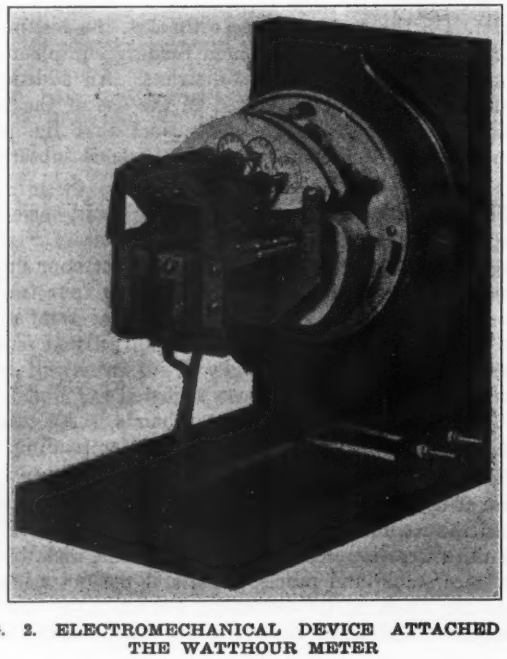


FIG. 2. ELECTROMECHANICAL DEVICE ATTACHED TO THE WATTHOUR METER

COMPLETING 100,000 mi. of test run, the first locomotives fully equipped on all axles with Timken tapered roller bearings recently pulled into the Seattle Terminal of the Northern Pacific R. R. Since April, 1930, it has been hauling the heaviest freight and fastest passenger trains on many of the principal railroads of the country with no instance of bearing trouble. Lower maintenance cost than for solid bearings has been demonstrated with less labor for lubrication. Reduced friction has permitted better starting ability and acceleration, also higher running speeds. Vibration and side sway are reduced. The locomotive was designed by the Timken Roller Bearing Co. of Canton, O., to demonstrate the ability of its product to give satisfaction in this severe service.

SMALL VACUUM cleaning outfits help keep the plant clean and, by getting rid of the dust, eliminate a fire and explosion hazard.

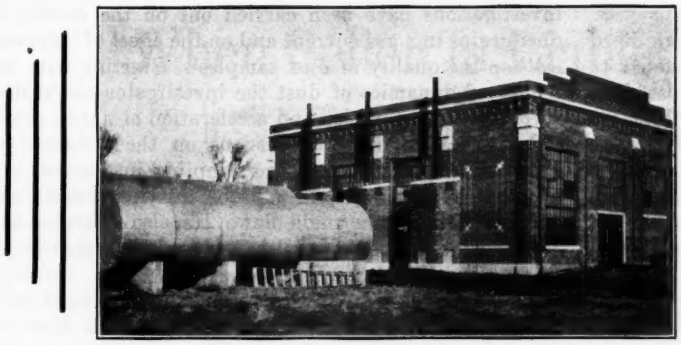


Fig. 1. Diesel Generating Plant of Harlan Municipal Utilities

Power Production of 11.02 kw-hr. per Gal. Fuel Oil and 1850 kw-hr. per Gal. Lubricating Oil, Heating of Station with Exhaust Heat, Flexible Lubricating Oil System Are Features of 1500-hp. Municipal Diesel Plant

Harlan Diesel Plant Earned $29,765 in 1930

NET PROFIT earned by the Diesel municipal power plant of the Harlan Municipal Utilities, City of Harlan, Iowa, for 1930 was $29,765.45, according to the records of the station. Total capacity of the plant is 1500 hp. in three engines of 375-b.hp., 500-b.hp. and 625-b.hp. capacity. Operating costs for 1930 as listed in the accompanying table, show that during that year the plant generated 1,710,500 kw-hr., of which 1,393,789 kw-hr. were accounted for, leaving the balance of 316,711 kw-hr., or 17 per cent of the total, to be attributed to line losses or other distribution losses. Production cost for this power was $0.00892 at the switchboard.

During 1930 the average net station output per 24 hr. was 4686 kw-hr., with a corresponding daily house load of 480 kw-hr. Load factor of the plant, according to the records, averages about 23 per cent, while the load factors of the generating units are as follows: 250-kw. unit, 59.1 per cent; 340-kw. unit, 70.8 per cent; 430-kw. unit, 66.5 per cent; average 65.4 per cent.

Three Fulton 4-cycle air-injection Diesel engines are installed. They are of 3, 4 and 5 cylinders, rated at 375, 500 and 625 b-hp. respectively or 125 b-hp. to the cylinder. They drive 250-kw., 340-kw. and 430-kw. generators at 225 r.p.m. These generating units in 1930 produced 11.02 kw-hr. per gal. of fuel oil and 1850 kw-hr. per gal. of lubricating oil.

Fuel oil, averaging 19,000 B.t.u. per gal., 34 deg. Beaume, is stored above ground in horizontal storage tanks with capacity of 65,000 gal. From these tanks it is pumped to three overhead hour storage tanks mounted on the building wall above the engines. An unusual feature of the arrangement is that the tanks are interconnected and a small rotary pump, controlled by a float switch, keeps them filled. Fuel flows from them by gravity through Fulton twin felt filters, then through a ⅛-in. Empire oil meter and then to the suction of the fuel injection pumps.

Lubricating oil is purified by a Sharples centrifuge. Two small Viking pumps transfer the oil to and from the sump tanks, the pumps being piped so that oil can be pumped from barrels through the centrifuge, then to the sump tanks of the individual engines, or oil can be pumped out of any sump tank into barrels when the tank is to be cleaned. Oil can be transferred from one sump tank to another, if desired, the oil being centrifuged as the transfer is made. Besides this, oil can be pumped from any sump tank, run through the centrifuge and sent back to the same sump. Finally, the two pumps can be used to pump oil to any desired point without passing it through the centrifuge.

Cooling water for the Diesel cylinder jackets is circulated in a closed system and is cooled in a concrete cooling pond with spray system. In hot weather the cooling water temperature may be 100 deg. F. entering and about 120 deg. leaving. Storage capacity for 80,000 gal. of water is provided. Normal makeup is about 1000 gal. per 24 hr. Water is treated in a Permutit

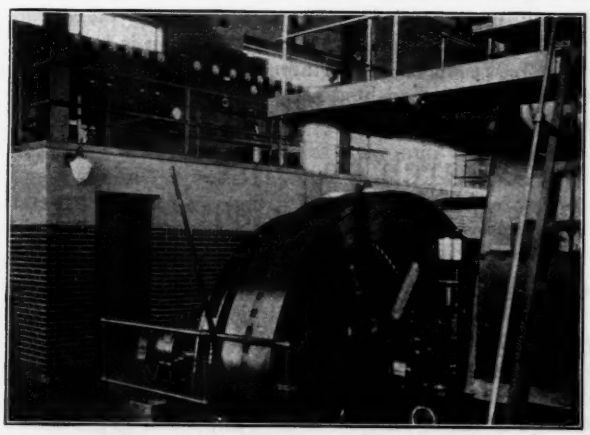


FIG. 2. INTERCONNECTED DECKS AROUND ENGINE TOPS ALSO CONNECT WITH SWITCHBOARD BALCONY

softener of 7200 gal. capacity and 28,800 gal. of makeup a day can be provided if required.

Air for the Diesel engines is filtered through Reed air filters. The exhaust pipes are water jacketed to the end of the engines, which exhaust through cast iron mufflers set inside brick housings just outside the main building, as shown in the headpiece. Heat from the engine exhausts is used to heat the building. To do this, the brick exhaust chambers containing the mufflers are connected to the building at top and bottom by air registers. In each bottom or cold air register a circulating fan is placed and this fan drives air through the space around the muffler and out at the top register into the room, the air being heated in the process by the heat from the muffler. The arrangement is in principle and effect much like a unit heater. The plant has gone through two winters with this heating arrangement and unless the weather gets much colder than it has been during those winters, it is felt that the system

TABLE SHOWING STATION GENERATION REPORT FOR 1930, HARLAN MUNICIPAL UTILITIES

KWH GENERATED	1,710,500.				
FUEL OIL USED	155,197.	GALLONS @	$0.0464	COST	$ 7201.10
LUBRICATING OIL USED	924.50	GALLONS @	$0.50	COST	462.25
RAGS USED	656.	POUNDS @	$0.16	COST	108.84
COOLING WATER USED	782,940.	GALLONS @	$0.256	COST	201.50
MISCELLANEOUS EXPENSE					182.50
PLANT LABOR and Supervision					7116.00
EXTRA LABOR					.00
TOTAL COST					$ 15,272.19
KWH PER GALLON FUEL OIL For the year	11.02				
KWH PER GALLON LUB OIL " " "	1850.	KWH Generated			1,710,500.K.W.
COST PER KWH DELIVERED " " "	$ 0.00892	KWH Accounted for			1,393,789.K.W.
AVERAGE GENERATION PER DAY " " "	4686.	Line Loss 17% or			316,711.K.W.

will take care of the heating requirements satisfactorily. It has the further advantage that aside from the first cost of fans and registers, it costs nothing except for a small amount of fan power.

Another interesting feature of the plant is that the decks around the tops of the engines are connected so that the operator can go from one engine to another without going down to the engine room floor. The switchboard is on the level of the engine decks and can be reached directly from them by a walkway, as shown in Fig. 2. It is on a balcony with the oil switches directly underneath in a fireproof room.

This power plant of the City of Harlan is in charge of G. J. Woodhouse, superintendent of light and power, to whom we are indebted for the data contained in this article.

Research on Dust Measurements

By Dr. Walther Parey*

WHEN MEASURING dust in industrial or power plants it is mostly impossible to measure the whole flow of gas which carries the dust. One can only take test samples from parts of the flow and draw therefrom deductions as to dust content of the whole flow. The method of taking samples is most important to get accurate results.

*Berlin, Germany, correspondent.

In the Technical University of Breslau (Germany) investigations have been carried out on the motion of dust grains in a gas current and on the effect of "dynamics" on the quality of dust samples[1]. Starting with the theory of dynamics of dust the investigator established formulas for the motion and acceleration of a dust grain. From these he drew conclusions on the influence of speed in the flow through the sampling instrument and of the angle between the axis of this instrument and the direction of the main flow. He also found a new formula for the centrifugal effect on dust grains in air filters, elbows and the like[2].

These theoretical considerations were proved in a number of practical tests. A ventilator fan blew air into a duct with two elbows. The amount of air was measured by an orifice, while the amount of dust was weighed and the time used to add it to the air flow observed. At five different positions, in the straight part of the channel, also before and behind the elbow measurements were carried out at twenty-five points of each cross section. In this way it was possible to investigate all different local influences in the duct.

Results showed particularly the influence of the elbow and of the vertical and horizontal direction of the dust motion. The usual precaution to measure at some distance before or behind elbows is right. But, if it is impossible to take dust samples at any other part of the channel, accurate results can be obtained even in the neighborhood of elbows, if the samples are taken across the whole cross section of the elbow and if the velocity of flow of the sample is equal to that of the main current.

In horizontal currents the dust arrangement becomes changed because of the gravity effect on the dust grains of different sizes. If it is necessary to know the average size of dust grains, it is, therefore, advisable to take samples in vertical currents where gravity does not affect the arrangement of the dust content of the flow. In horizontal ducts, accurate results on the size of dust are obtainable only by a sufficient number of samples taken in the direction of segregation by gravity action.

Most important in its influence on the accuracy of dust measurements is the velocity of flow of the samples into the sampling instrument. This must be as nearly equal to that of the main flow as possible. If equality is impossible, it is advisable that speed of the sample be somewhat higher than that of the main flow because this makes for greater accuracy of measurement than the opposite condition.

Furthermore it is necessary that the axis of the sampling instrument be parallel to the direction of the main flow. The sampling pipe should be put into the dust current only while taking samples because dust flies into the instrument by its own momentum, even if no gas flow is passed through the instrument. This may falsify the results when sampling is started.

[1]The Dynamics of Dust and Their Influence on Dust Measurements, Dr. W. Fahrenbach, VDI-Berlin, Vol. 2, 1931, page 395.
[2]Precipitation of dust on plane bodies and in air filters, Dr. W. Sell, VDI-Research Publication No. 347.

High pressure and corresponding high saturated steam temperature cause the combustion gas to leave the last boiler pass at high temperature. The higher the exit gas temperature, the greater the need for heat recovery the greater the actual recovery and the greater the opportunity for profitable heat return to the furnace.

When Seller Is Liable for Guarantee

CLASSIFICATION AND DEFINITIONS OF GUARANTEES; RULINGS ON LATENT DEFECTS; PROMPTNESS OF COMPLAINTS. BY LEO T. PARKER*

RECENTLY I have received several inquiries from engineers, who have some or complete authority to purchase power plant equipment. These engineers have requested legal information of the liabilities of the sellers who supply defective and unsatisfactory products on which no guarantee is given; therefore, I shall review the leading and recent higher court decisions on this subject.

First, it is important to know that the law presumes every person to be honest and trustworthy until proved to the contrary. Frequently, the character of a contract or the intended use of the device is such that a purchaser is compelled to rely upon the honesty of the seller to supply equipment reasonably fit for the intended special purposes. Under these circumstances, the courts imply a warranty on the part of the seller that he will supply a good product in consideration of the price paid.

In other instances, the courts have held that sellers impliedly warrant that the equipment they sell is fit for the *general* purpose for which it is sold, as well as for the buyers' *special* purpose.

CLASSIFICATION OF GUARANTEES

In fact, guarantees are in two legal classifications, namely, expressed and implied. An expressed guarantee is one where the buyer and seller have orally or in writing agreed to the exact terms of the warranty. An implied guarantee is one where the seller does not make a warranty, but the circumstances are such that a court implies that a warranty exists irrespective of the contrary contentions of the seller.

Generally, the outcome of a litigation involving an expressed guarantee depends upon the court's interpretation of the original intentions of the parties at the time the contract was completed, whereas the courts imply a guarantee only where it is necessary to render a verdict fair and impartial to the buyer.

Also, it is important to know that the courts interpret an expressed guarantee strictly in accordance with its legal meaning. This is particularly true if the party who refused to fulfill the terms of the agreement offers the excuse that he did not understand the legal obligations of the guarantee, or that he did not read the contract. In other words, the courts will not permit any person to avoid liability on a contract that he fails to exercise care to understand thoroughly.

DEFINITION OF IMPLIED GUARANTEE

An implied warranty never is agreed upon by the parties to a contract. It is not a contractual obligation, but a common law right invokable by the buyer under various circumstances consistent with the present legal policy of "right is might." The courts assume the existence of an implied guarantee where it is practical to do so for the purpose of protecting legal common law rights of a buyer. A review, however, of the details of recent higher court decisions involving various phases of the law on this subject probably will convey the desired information better than mere explanation.

In a recent case (140 S. E. 653), a manufacturer sold a machine which he said would perform a special service in addition to its general and usual operations. Later, the buyer discovered that the machine would not perform the special purpose satisfactorily, as its operation was too slow to prove profitable to the user. The machine, however, would satisfactorily perform other work for which it was generally intended.

Contending that the implied warranty rule was applicable, the buyer refused to pay for the machine. The manufacturer argued that he was not liable for a guarantee since the machine was adapted to perform its usual functions and since he gave no absolute warranty that it would satisfactorily perform the special function. The court, however, held the seller liable for an implied guarantee and stated the following law:

"When one contracts to supply an article in which he deals, to be applied to a particular purpose, so that the buyer necessarily trusts to the judgment or skill of the vendor, there is an implied warranty that it shall be reasonably fit for the purpose to which it is to be applied."

In still another recent case, Trunk v. Stewart, 262 Pac. 143, it was disclosed that a salesman booked an order for a mechanical device. Before giving the order the purchasing engineer explained to the salesman the use he intended to make of it. The salesman by authority of his employer stated that the machine would accomplish the desired work. Later, the purchaser discovered that the machine would not perform satisfactorily and he refused to pay for it. He immediately communicated with the seller and requested him to send for the machine. The seller refused to do so and filed suit contending that the machine would prove satisfactorily to a reasonable user. The court held the buyer not required to pay for the machine, saying:

"Here is an express finding that there was a warranty and an agreement to take the machine back in the event that it did not do the work satisfactorily. . . . There is no legal reason why the parties, if they saw fit, could not enter an express oral warranty and agreement to take back in the event that the machine was not satisfactory. . . . The respondent (buyer) did all that he was required to do when he notified the seller to remove the machine."

It is important, however, to know that a buyer cannot expect a seller to determine by deduction the purpose to which he intends to put purchased merchandise.

In other words, a buyer is not legally entitled to hold the seller responsible for unfitness of purchased equipment, where the latter was not clearly informed of the uses intended to be made of the goods.

On the other hand, if the seller is familiar with the

*Attorney at Law, Cincinnati, Ohio.

engineer's requirements when the sale is completed the court may imply a guarantee although the latter did not explain to the seller or his authorized agent the intended uses of the equipment.

A manufacturer is not liable for latent defects, although he knows the purposes which the buyer intends to make of the equipment.

For example, in United States Fidelity & Guarantee Co. v. Western Iron Stores Co., 220 N.W. 192, it was shown that a seller of chain was familiar with the requirements of the purchaser who intended to use the chain for the purpose of lifting approximately 1600 lb. The chain proved defective and broke, permitting the load to fall. In holding the manufacturer not liable for an implied guarantee, the court said:

"It must be a matter of common experience that, no matter what care is exercised in the manufacture of chains or other like articles of commerce, there will be occasional latent defects, and, when a buyer orders goods sold in the markets by description, specifies nothing in regard to the qualities of the goods purchased, except that they shall be such as answer the description given, and the goods of such description are delivered, there is no implied guarantee that latent defects which can be discovered, if at all, only by tests, do not exist. . . . The seller warrants only that they are of the kind and character which he was to deliver under his contract."

Moreover, a manufacturer is not liable for statements made by salesmen, unless such statements are authorized or approved by the employer. Also, this is true with respect to unsigned printed guarantees sent with merchandise.

The Rule of Caveat Emptor

Caveat emptor does not mean that the buyer is justified in taking a chance. It means "Let the buyer beware." Generally, this term applies to the purchase of specific things the quality of which the buyer, when making a purchase, can and usually does exercise his own judgment. It applies also whenever the buyer voluntarily chooses the thing he is purchasing without demanding an expressed guarantee.

It never, however, has application in any contract where the buyer has trusted the seller to supply merchandise to be used for a purpose known to the seller at the time of the sale.

On the other hand, a buyer cannot rely upon the law to assist him where he knowingly purchases unfit equipment and later decides he will not fulfill the terms of the contract.

For instance, in Paul v. Salisian, 262 Pac. 779, a buyer examined that which he intended to purchase and found it to be of inferior quality. He proceeded to make a valid contract of sale, and later he examined the article more carefully and discovered that he had made a poor bargain.

He then refused to accept and pay for the subject of the sale, contending that the seller had misrepresented facts and that the law implied that the article was of reasonably good quality. The court, however, held the buyer bound by the terms of the contract, saying:

"It is also well established that where a purchaser fails to exercise ordinary care to know that merchandise is defective, he is not permitted to sue and recover the purchase price on the implied warranty rule."

The same law is applicable with respect to purchasers of second-hand equipment.

Purchaser Bound to Complain Promptly

Still another important established point of the law is that a purchaser, who intends to invoke the rule of implied guarantees, is bound to submit complaint of his dissatisfaction promptly to the seller.

For illustration, in McCaskey Co. v. Cawood, 2 S. W. (2d) 639, it was disclosed that a purchaser kept and used a device for three months, when he decided to return it to the seller because certain parts were missing. This court promptly held the buyer bound to fulfill the terms of the agreement and stated the following important law:

"The law is well settled that it is the duty of a buyer to inspect goods which he has purchased upon delivery, and, if there are any defects which are apparent and he retains the goods after discovering the defects without notifying the seller of the defects, he cannot defend an action for the purchase price upon the grounds that the goods are not as represented. An acceptance of the goods after an inspection, or a reasonable opportunity to inspect, is a waiver of any breach or warranty in the contract of sale."

How Implied Warranty Is Cancelled

The legal effect of an implied warranty is cancelled by a written or verbal agreement between the buyer and seller in which it is clearly understood the seller does not impliedly guarantee his product.

In International Co. v. Bean, 169 S.W. 549, the contract, after distinctly specifying the expressed guarantee, stated:

"This express warranty excludes all implied warranties."

The court held that this clause prevents the buyer from relying upon the law that a seller implies a warranty in addition to the expressed guarantee.

In another leading case, Oldfield v. International Co., 138 Md. 35, the implied warranty was excluded by the court on proof that the written contract provided that "no guarantee express or implied is made by the company."

In Bekkevold v. Potts, 216 N.W. 790, however, a contract of sale contained the following clause:

"No warranties have been made by the seller to the buyer unless expressly written hereon at the date of purchase."

The contract contained no written guarantee and later, when the purchaser discovered that the article was defective, he sued to recover the purchase price on the contention that the seller impliedly guaranteed his product.

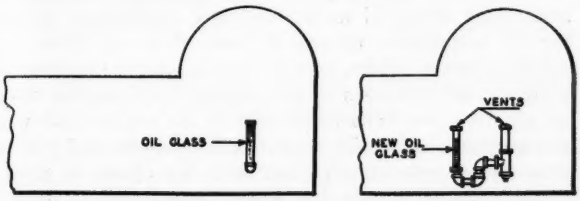
It is interesting to observe that the court held that this clause does not exclude an implied warranty, saying:

"We are of the opinion that the parties intended to say that no contractual warranties had been made, that the seller had not spoken or written any warranty in reference to the outfit. There was no other way by which such warranties could have been 'made'. . . . We must conclude that the parties did not intend to exclude the implied warranty which could easily have been done in unmistakable terms had they so chosen."

Readers' Conference

Crankcase Oil Level Gage

OUR NEW boiler plant has installed two 8 by 10 in. horizontal blower engines. These engines employ the splash type of lubrication; i.e., the action of the crank splashes oil from the crankcase up to two oil wells, one of which feeds the main bearings and eccentric and the other, the crosshead slippers and piston pin.



OLD AND NEW OIL LEVEL GAGE ARRANGEMENT

At the bottom of the crankcase was a vertical oil glass with a 1/32-in. vent hole. When the engine was running the oil in the crankcase was in such a state of turbulence that an accurate indication of the amount of oil in the crankcase was impossible, due to the bubbles in the oil glass. Sketch A will give an idea as to the layout.

To overcome this inaccuracy, the oil glass was changed in the following manner: Originally there was a ¾-in. tapped hole in the crankcase, the fittings used were a ¾-in. butt nipple, a ¾ by ¾ by ⅜-in. tee looking up, a ¾-in. butt nipple and ¾-in. gate valve, for draining crankcase. The oil glass screwed into the ⅜-in. branch of the tee.

The new method tried and found successful was to take out the oil glass and screw in a close ⅜-in. nipple and ⅜-in. tee, then insert a ⅜-in. nipple the height of the original oil glass. This nipple was capped and a 1/32-in. hole was drilled in the cap for a vent. Onto the side outlet of the ⅜-in. tee was screwed a ⅜-in. close nipple, a ⅜-in. elbow looking down, another ⅜-in. close nipple on another ⅜-in. elbow looking towards the steam cylinders. Then a ⅜-in. close nipple and elbow looking up were screwed on. The oil glass was screwed in this elbow and the result was a gage that gave accurate indications at all times.

When the engine is running, the oil bubbles and foams in the ⅜-in. standpipe, but the bubbling and foaming never carries over to the oil glass. The oil glass now looks about like sketch B.

Poughkeepsie, N. Y. WILLIAM E. HELMER.

Steam Flow Meter with Variable Capacity

IN THE ACCOMPANYING sketch is shown a piping arrangement which permits a steam flow meter, on a widely varying steam flow, to register well up on the scale with light load, and yet hold the high peaks down on the chart with the same accuracy.

The problem which brought out this scheme was that of metering low-pressure steam to a heating main, where the flow is at times only 3000 or 4000 lb. per hour, but will run up to peaks of 45,000 lb. per hr. The pressure also will vary from 8 to 9 lb. gage pressure at light load to 30 or 35 lb. with heavy loads. The dilemma is, of course, that if the scale of the meter is high enough to register the extreme peaks, then the light load readings will be so low as to be inaccurate, whereas, if the scale of the meter is low enough to get satisfactory readings at light load, then the peaks will be beyond the capacity of the meter.

Finally the problem was solved by setting the meter with a scale of convenient size to register average and light loads only. A third condenser was then installed exactly 30 in. above the regular condenser on the down stream side of the meter with two ¼-in. valves so placed that either the upper or lower condenser may be cut in or out merely by opening and closing these valves. The upstream side has the usual connection and single condenser.

In operation, with normal, average or light loads, the third condenser is not in use and has no effect on

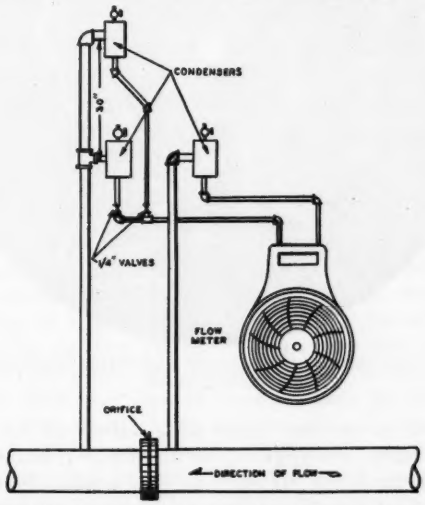


FIG. 1. DIAGRAM FOR INSTALLING THIRD CONDENSER ON STEAM FLOW METER TO INSURE GREATER ACCURACY AT EXTREME LOADS

the registration of the meter. During peak loads, when the flow meter pen would otherwise go off the chart, the lower condenser on the downstream side is closed off with the ¼-in. valve, and the upper condenser is turned on. The differential pen immediately drops back exactly 30 in. and continues on, making a true graph of the load except, of course, that all parts of the curve should now be read 30 in. high. When the peak is over, the two ¼-in. valves are switched back again cutting out the upper condenser and putting the lower one back into service, when the pen immediately jumps up 30 in. and proceeds with the correct curve as before.

At this writing, extreme peaks have not yet been reached but to prove the workability of this connection several charts were made using the third condenser for a short time to illustrate results. On the accompanying

chart, the third condenser was cut in at 8:13 a. m. and cut out again at 9:00 a. m. The differential curve clearly indicates where this change was made and 30 in. should be added to the curve values during this period.

The added differential of 30 in. was chosen in this case, as convenient for the particular load involved, though a height of 40 in. or 50 in. might be used with equal accuracy. With an added 50 in. on a 50-in. capacity meter, however, too strict attention might be required from the operator at times when the actual differential reading would vary around a 50-in. reading. On a 50-in. meter an added differential of 30 or 40 in. would probably be more satisfactory or on a 100-in. meter around 60 to 80 in. additional.

With extremely variable loads it would be possible to use a fourth condenser 30 or 40 in. above the third

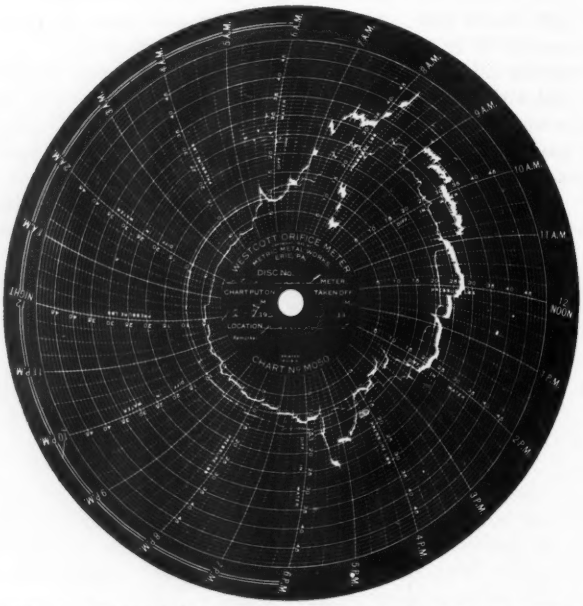


FIG. 2. RECORD FROM METER SHOWING USE OF THIRD CONDENSER

one and so produce three scale values on the meter. Or, of course, one might go on up to 5 or 7, being limited only by the steam pressure and the height of the building, but for practical purposes the third condenser will provide a satisfactory extension of 60 to 80 per cent on any differential type flow meter and will be applicable to many such loads.

Springfield, Mo. R. E. THOMPSON.

Economics of Diesel Air Filtration

FILTRATION of air supply for Diesel engines usually pays. No Diesel plant should be contemplated without giving serious thought to this subject. Many Diesel engine builders are now including an air filter as standard equipment with an engine or definitely advising its use with the engine.

Economy of installation may be demonstrated by the experience of a large Texas electric generating station in which two 1250-hp. Diesel engine units carrying base load are installed. The air supply in the vicinity of the plant carries much sand and dust. Installation of proper air filters resulted in doubling the valve grinding period, saving $56.66 a year in direct costs. Liner replacement interval was increased from 3 to 4 yr., saving $466.66 in direct costs, making a gross saving of $523.32 for the year. Against this is charged a total filtering cost of $188.37, making a net return of $334.95 or 34 per cent. Fixed charges for depreciation and average interest can be based safely on a 20-yr. life, amounting to $80.23 on an installed cost of $984.29.

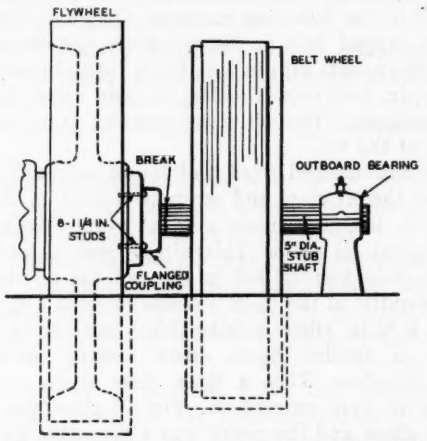
Besides these direct savings, the installation increased the operating time and improved the running conditions. It decreased the wear on other minor parts of the engine and reduced the labor charge for maintenance.

Tests made by the United States War Department on two automobile type engines which were exact duplicates and which operated under identical conditions, except for the installation on one of them of an air filter, resulted, after a 240-hr. run, in the following conditions: wear on the cylinders of the engine not equipped with an air filter was nine times that of the engine that was so equipped. Also the wear on the pistons and piston rings were, respectively, four and ten times as great. Carbon deposit in the first engine was found to be approximately five times that of the filter-equipped engine.

Wheaton, Ill. EDWARD J. KUNZE.

Causes and Remedy of Stub Shaft Breakage

JUST TEN WEEKS after a certain 240-hp. Diesel was installed, the stub shaft broke close to the flange coupling, which was bolted to the flywheel. This shaft was



ARRANGEMENT OF STUB SHAFT AND FLYWHEEL HUB, WHICH WAS FOUND TO BE OUT OF TRUE

5 in. in diameter and carried a belt wheel 60 in. in diameter, 26 in. wide. The engine drove two 12 by 12-in. ammonia compressors with a short belt drive, using an idler on a 24 in. belt. After the stub shaft broke, the general impression was that the shaft had not been properly lined and leveled, so another shaft was put in. It was checked carefully and the engine was started again. This shaft broke after running 11 days.

Then the general opinion was that the shaft was too light and that a heavier shaft would overcome the trouble. The argument was that the chatter from the belt idler caused the shaft to crystallize and break. This time a shaft of 6½ in. diameter was made up and installed. This shaft seemed to run perfectly and tests for vibration or strain were made. The instruments showed

neither and it was believed that the trouble had been stopped.

After six months operation, however, this third shaft broke just as the others had, indicating that probably the cause of the trouble still existed. The shaft was removed, the studs were taken out of the face of flywheel hub and an indicator was set up to check the face of this hub. The engine was turned over by hand and the indicator showed that the face of the flywheel hub was 0.013 in. out of true. Tools were set up to true this face right on the engine and after this had been done, a new shaft of 6½ in. diameter was installed. This shaft has been in constant use now for two years and is still giving perfect satisfaction.

Kansas City, Kan. J. F. STALEY.

Cutting Belting Costs Through Good Maintenance

BELTING presents a rich field for worth while savings, due to the fact that in some plants most, or all of the power is transmitted through the medium of belting. It is therefore evident that belting will become a major item of expense, through the addition of costly delays and accidents added to the belt costs, if it is not properly maintained.

We usually have a way of singling out one of our perplexing problems, concentrating on it until, if we are successful, it is solved. Let's see what it means when we tackle the belting problem.

"Properly maintained" is a big term and covers far more ground than we are likely to suspect, until we make a thorough inspection and study of the installation. For the want of a better name we might call it a belting survey divided into several successive steps.

1. Cost study per unit or ton of the manufacturer's product. How do they compare with the best practice in similar plants?

2. Make sure that belting fits the service to which it is put and is properly installed.

A few cost reduction items that can be immediately put into operation are as follows:

3. A reliable mechanic who will take an interest in the belting installation should be put in charge of it.

4. Keep drive belts dry.

5. Keep oil off belts.

6. Aline pulleys so that belts will run true without rubbing stationary objects.

7. Belt joints should be cut square and joined evenly to prevent wabbling.

8. Belt dressing should be used only to lubricate the fibers and preserve the belt in a pliable condition.

9. Run belts as slack as possible. A belt should operate wherever possible with the tight side on the bottom. This condition removes excessive strain from the belt, bearings, pulleys, and shafting, resulting in less maintenance and longer life of each.

10. Check, re-aline, and level all pulleys and shafting where necessary, and see that the pulleys are of the proper width for the belt. When the above-mentioned items have been checked and corrected as far as possible a second survey of all drives can be started to see how they compare with up-to-date installation practice. This survey should cover the following items:

1. Check all belts to see if they are of the correct size to carry the load.

(a) Make a load test to determine the horsepower transmitted.

(b) Check pulley ratios to see that they are within the recommended sizes.

(c) Check center distance between shafts.

(d) Check belt speed in feet per minute.

With this data to work from the right belt can be installed.

2. Check type of belt hooks being used with the view in mind of obtaining a more serviceable fastener. This should be a fastener that will not cut the plies too badly when being installed. Wherever practical, endless belts should be installed to eliminate the hook evil and obtain a smoother running belt.

3. Check types of belts in use to see if they fit the drive and operating conditions. In most cases, this will require the services of a belting engineer.

4. Investigate the savings to be made by replacing some of the drives that are unsuitable for the straight belt with the "V" belt drive.

5. Establish a belt record system upon which all data and other information relating to the drive may be recorded. This is important if belting costs are to be controlled, and to insure the right belt being installed.

First cost in most plants will prohibit the immediate correction of all belt drives. This, however, should be the ultimate aim of the belt maintenance program. A good rule to follow in obtaining this end is to make all new drives right. This will include any changes or renewals in the installation also.

Niagara Falls, N. Y. MARIN PHILLIPS.

Pressure Drop Across Steam Purifiers

AFTER THE INSTALLATION of a steam purifier for the purpose of removing impurities from the steam, it is often thought that this will be a permanent cure for all troubles of this sort and no further difficulty will be had. The purifier will serve its purpose well but there is one precaution that should be taken after installing one of these in a line. A pressure gage should be connected just ahead of the purifier and another one just after it. These gages should be brought down to a panel where they will be easily observed and a daily, weekly, or monthly record of the differential pressure kept, the time interval depending on the conditon of the steam, the design of the separator and the per cent of capacity at which it is being worked. This record should determine how often it is necessary to remove the purifier element for cleaning.

Under no conditions should the pressure gage between the purifier and the point of steam generation be omitted. If this is done and the purifier becomes clogged up and safety valves are not properly set or in poor operating condition, excessive pressure may result.

Most purifiers may best be cleaned by disassembling, soaking in a warm solution of muriatic acid for several hours and scraping while the accumulated scale and impurities are still soft. The allowable pressure drop before cleaning is necessary will vary in different services but an average of 10 per cent of operating pressure may be taken in most cases.

Milford, N. J. H. M. SPRING.

Plant Operation Problems

Pumping Brine and Water

WHAT IS the relative power consumption required to pump a certain weight of water and brine against a definite pressure? For instance, 3000 lb. per min. against a pressure of 125 lb., the density of the water being 62.5 and of brine 73.2 lb. per cu. ft. (Specific gravity 1.17). A. L. E.

A. Power consumption for pumping under these conditions would vary inversely as the density of the fluid and the water pump would require $73.2 \div 62.5 = 1.17$ times as much power as the brine pump.

A cubic foot of the brine weighs 73.2 lb. which gives a unit pressure of $73.2 \div 144 = 0.5075$ lb. per sq. in. pressure for each foot head of brine. Pumping against a pressure of 125 lb. would be equivalent to pumping to a height of $125 \div 0.5075 = 246$ ft. This work would be the same as lifting 3000 lb. per min. to a height of 246 ft., or $3000 \times 246 = 738{,}000$ ft. lb. per min. One horsepower is equal to 33,000 ft. lb. per min. so that the brine pump would require $738{,}000 \div 33{,}000 = 22.35$ hp. under ideal conditions. With a pump efficiency of 60 per cent, the actual power would be $22.35 \div 60 = 37.2$ hp.

Water with density of 62.5 lb. would exert a unit pressure of $62.5 \div 144 = 0.434$ lb. per in.; that is, a column one foot high with a 1-sq. in. cross section would exert that pressure or stated another way it would take a column $1 \div 0.434 = 2.31$ ft. high to exert a pressure of 1 lb. per sq. in. A pressure of 125 lb. would be equivalent to a column of water $125 \div 0.434 = 288$ ft. high. To pump 3000 lb. per min. to this height would take $3000 \times 288 = 864{,}000$ ft. lb. per min. or $864{,}000 \div 33{,}000 = 26.3$ theoretical horsepower. With a pump efficiency of 60 per cent, this would be increased to $26.3 \div 0.60 = 43.6$ hp.

Power consumption is thus seen to be in the ratio of 43.6 to $37.2 = 1.17$ or inversely as the densities, that is, the higher the density the lower the power requirements. This problem involving pounds of fluid against a given pressure in pounds per square inch should not be confused with problems involving volumes and heads in feet. It is always well to reduce the amounts pumped to pounds and the discharge pressure to feet head of liquid and calculate the power requirements as indicated above.

Sulphur in Diesel Fuel

I WOULD like to learn from engineers who have had experience with Diesel engines, especially those who have burned fuel oil (not Diesel oil) in their engines, what they consider the limit of sulphur allowable in the oil that will be satisfactory from the point of view of maintenance.

L. E. H.

A. Tentative specifications of the A. S. M. E. Research Committee on Fuel Oil Specifications are given in the following table:

	Heavy Duty Engines	Light High Speed Engines
Viscosity at 100 deg. F. Saybolt Sec.	Max. 220 Sec.	Max. 100 sec. Min. 45 sec.
Sulphur, per cent, maximum	3	2
Conradson, per cent, maximum	4	1
Ash, per cent, maximum	0.08	0.02
Flash, deg. F., minimum	150	150
Moisture and sediment per cent	1	5

United States Navy Specifications covering oil used by the government and its agencies state that "sulphur shall not be over 1.5 per cent, method 520.21."

The easiest method of preventing this corrosion is to keep on hand a small quantity of the higher grade Diesel oil or kerosene and to use it for the engine fuel a few minutes before shutting down and likewise upon starting. This eliminates the danger of sulphurous-acid gas remaining in the cylinder during the cooling down period and its formation during the warming-up period, for kerosene contains no sulphur to unite with the water vapor.

If any reader has additional data on this subject that he thinks would be helpful to L. E. H. and to Power Plant Engineering's readers, his comments will be most welcome.

Steam Required for Heating Water

WE HEAT water in a tank which is 384 in. long by 120 in. wide by 18 in. high and, wishing to determine the amount of steam required, secured the following data: Steam pressure, 142 lb. gage; temperature of water in tank at 5 p. m. when run was started, 88 deg. F.; temperature at end of run, 7 a. m., 143 deg. F.; depth of water in tank at start 12.75 in. and at end of run 15.5 in.; atmospheric temperature ranged from 19 to 28 deg. F. The only water added was condensate from the steam used to heat the water. We would like to know the amount of steam required, also the B.t.u.

H. G. M.

A. By subtracting the original depth of water from the final we find the depth has been increased 2.75 in., or the volume increase is $384 \times 120 \times 2.75 = 123{,}970$ cu. in., or dividing this by 1728, reducing to cubic feet, and multiplying by 62.5 gives us the pounds of steam used, or 4585.25 lb.

From the steam tables we find that the total heat above 32 deg. F. in 1 lb. of saturated steam at 142 lb. gage pressure is 1195.4 B.t.u. and 1 lb. of water at the final temperature of 143 deg. will have $143 - 32 = 111$ B.t.u. of heat above 32 deg. F. The amount of heat given up per pound of steam is then $1195.4 - 111 = 1084.4$ B.t.u. or the total B.t.u. required during the run amounted to $1084.4 \times 4585.25 = 4{,}972{,}245.1$ B.t.u.. If it were not for radiation the amount of heat required would be calculated as follows: $384 \times 120 \times 12.75 \times 62.5 \div 1728 = 21{,}163.2$ lb. water to be heated. $21{,}163.2 \times (143 - 88) = 1{,}163{,}976$ B.t.u.

The heat lost through radiation is then $4{,}972{,}245.1 - 1{,}163{,}976 = 3{,}808{,}269.1$ B.t.u. This loss is not suprising when you consider your outside temperature and the size of your tank.

New Equipment

Test-O-Meter for Boiler Water

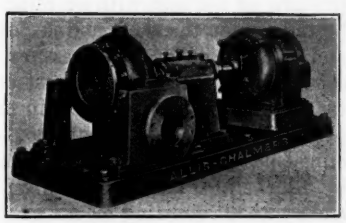
To SHOW at a glance, the concentration of mineral salts in boiler water, hence when to blow down the boiler, E. Edelmann & Co., Chicago, has perfected the Boiler Test-O-Meter. This provides means of withdrawing and holding sample of the water, with a built-in thermometer scaled from 60 to 120 deg. F., permitting a test to be made at any temperature within that range.

EDELMANN TEST-O-METER

As dirty water never touches the scale of the thermometer, it is always easy to read. Built-in is a correction table, which shows at a glance the amount to subtract from the float reading to determine the concentration. Also a conversion table, built into the jar containing the thermometer and correction scale, tells the amount of concentration of the mineral salts in both grains per U. S. gallon and parts per million, so that no calculations are necessary.

Pumps for Handling Acid

FOR HANDLING acids in process work, Allis-Chalmers Manufacturing Co., Milwaukee, Wis., is building



SPECIAL PUMP FOR ACIDS

a new pump of the single suction type with all parts coming in contact with the acid made of chrome steel. To insure uniform expansion from the center of the pump when handling acids of high temperature, the casing is supported on the horizontal center line by brackets, keyed on the vertical center line underneath the water cooled stuffing box. Rotating element including the bearings and the Falk coupling can be removed through the suction end of the pump without disconnecting discharge piping or casing brackets or disturbing the motor.

Vibration Recorder

SOMEWHAT LIKE the seismograph, a device for recording earthquake tremors, is the instrument developed in the general engineering laboratory of the General Electric Co. for measurement, in thousandths of an inch, of vibrations in steam turbines or other machinery to which the instrument is attached.

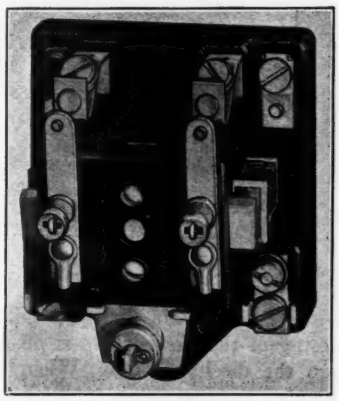
Within a case, which is bolted to the machine under investigation, is suspended a block of lead, with two tension springs on the top and four springs on each side to hold it in position. The outside shell of the detector vibrates at the same period as does the machine to which it is attached, but the lead weight, because of its mass and low natural frequency remains fixed in space.

In opposite sides of the lead weight are embedded two coils; in front of each coil is an adjustable piece of magnetic steel, fastened to the outer shell. Coils are energized by 500-cycle alternating current, air gaps between the coils and pieces of magnetic steel being adjusted so that the two coils are electrically balanced, the amount of current through the coils depending on the distance of the steel pieces from them. Reading of the indicating instrument is then zero when there is no vibration.

Vibrations of the machinery cause a swaying of the outer shell, thus varying the distances between the coils and the magnetic pieces, which causes a variation in the flow of the 500-cycle current that is translated into thousandths of an inch in vibration readings.

Small Capacity Contactors

TO MEET demand for a magnetic contactor of small ampere capacity, the Industrial Controller Division of the Square D Co., Milwaukee, offers two new sizes, designated Types H for 220 v. and K for 440 v., rating from 3 to 15 amp. for non-inductive load or fractional horsepower ratings for 110-v., single-phase motors. Features embodied in the design are: laminated magnet



SQUARE D CONTACTOR

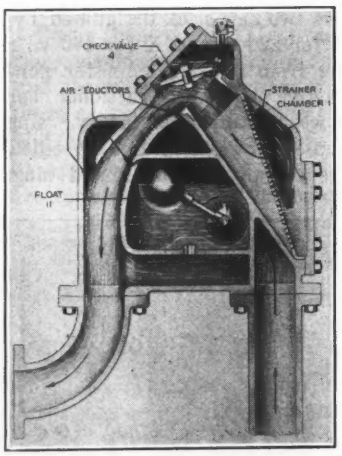
frames, floating armatures to insure quiet operation, silver to silver contacts, porcelain bases, approved temperature and insulation standards. Single and double pole, single and double throw, circuit opening and closing, two or three-wire control, and three-wire thermostat control are built for use with temperature regulators, oil burners, stokers, signal and lighting systems and small motors.

Suction-Line Primer

SUCTION-LINE PRIMER for centrifugal pumps, as shown in the illustration, has recently been placed on the market. It is designed to combine in one compact casting a check valve, strainer and air removing device. It is built in various sizes for a maximum capacity of 1600 g.p.m. and maximum operating head of 200 ft. When furnished with a special control panel, it is intended to make possible automatic operation of a pump and prevent loss of water, air

leaks, break of the column line, and the like.

In operation, pump and primer must be filled with water and when the pump starts it draws water from chamber 1, causing air from the suction line to rush through check valve 4 into the chamber. When the chamber is pumped empty, float 11 falls, tilts a mercoid switch and stops the pump. The water now rushes back from the discharge line, refills chamber 1 and the air trapped by the closing of the check valve is pushed into the discharge line. When the chamber is completely refilled the float rises, tilts the mercoid switch and again starts the motor. This primer is a new product of Barrett, Haentjens & Co., Hazleton, Pa.



SUCTION-LINE PRIMER

Oil and Gas Power Meeting to be at State College

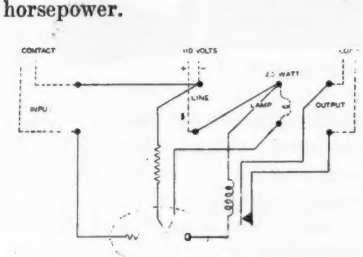
FIFTH NATIONAL Oil and Gas Power Meeting will be held at Pennsylvania State College, June 8 to 11, E. J. Kates, secretary of the A.S.M.E. Oil and Gas Power Division, has announced.

Pennsylvania State College is planning to have the usual exhibit of engine parts and auxiliaries in connection with the meeting. Prof. F. G. Hechler is the chairman of the local committee on arrangements, while Prof. Kalman De Juhasz will be in charge of the exhibit. The technical program is being arranged by the Division and is in charge of L. H. Morrison.

Mr. Kates announced that L. R. Ford, Columbia University, will continue as chairman of the Division and also that Ralph Miller, Ingersoll-Rand Co. who was appointed last year to fill an unexpired term, was reappointed for a full five-year term on the Division Executive Committee. Other members of the Division Committee are Harte Cooke, chief engineer, MacIntosh-Seymour Co., L. M. Goldsmith, Atlantic Refining Co., and L. B. Jackson, Fairbanks, Morse & Co.

Relay Works on 0.000,001 Amp.

SUPER-SENSITIVE control is secured by the Burgess Micro-Relay using an electronic tube with a 25-w. lamp as ballast in the grid-circuit. Thus one one-millionth of an ampere in the control circuit or one flypower is used to regulate the action of 6 amp. at 220 v. or over 1½ electrical horsepower.



BURGESS MICRO-RELAY CIRCUIT DIAGRAM

As shown in the diagram, the contact, made by thermometer, gage or other action, is in series with the tube grid circuit. 110 v. is used on the filament with the 25-w. lamp in series. 110 v. grid bias potential is placed between plate and grid when the contact closes. The plate circuit includes a relay, normally closed but held open by the residual value of plate current when the grid is unbiased. When the contact is closed and 110 v. grid bias applied, the relay closes, even though contact resistance is as much as 20 megohms.

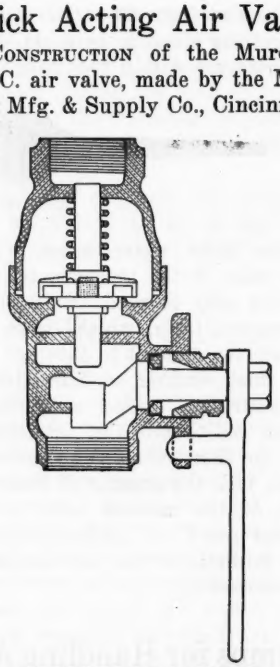
Parts of the relay are contained in a metal cabinet, 7 by 8½ by 4¼ in., with terminal strips inside for connection to external circuits and knockouts for BX or conduit connection. The 25-w. lamp serves as a ballast resistor, as pilot to show the relay to be operative and to light the indicating instrument which controls the left-hand contact.

Burgess Vacuum Contact is used for the mechanical relay, protecting points against oxidation and avoiding danger of ignition from sparking. Since the current through the grid contact is infinitesimal, there is no hazard of its sparking, or oxidyzing contact points and the slightest contact will operate the tube.

Time lag of some ½ sec. exists because of capacity effect between electrodes of the tube. This limits operation to speed of 120 times per min. but the lag is useful in preventing chattering in case of a contact which is super-delicate. Time lag may be increased by turning a knob which is part of the assembly, to meet any requirements of operation.

Quick Acting Air Valve

CONSTRUCTION of the Murdock Q.O.C. air valve, made by the Murdock Mfg. & Supply Co., Cincinnati,



MURDOCK Q.O.C. VALVE

Ohio, is shown herewith. The valve, which has renewable disc, is opened straight off the seat with no rotation by the cam on the shaft and is closed and held tight by air pressure as soon as the cam is turned past center. The spring is auxiliary in case of installation in horizontal or inclined position. Packing is adjusted by a large nut, repacking being possible without shutting off air or taking down the valve.

New Underfeed Stoker

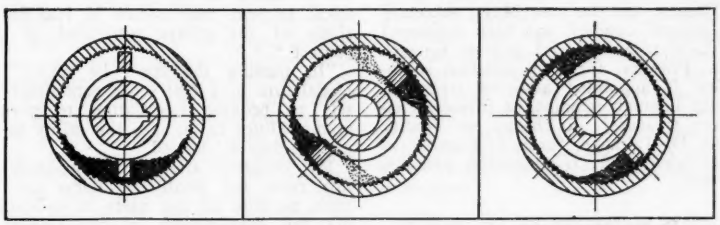
FEATURES of the Model R Riley Underfeed Stoker recently announced are a 2-speed gear box with machined parts and roller bearings, sectional hopper, with observation slots and individual section shut-off gates, grate surface to give greater

capacity and prevent sifting of coal to the air chamber, overfeed grates at the rear with regulated air flow, new design of heavier rocker dump, for manual or power operation, substructures free to expand and contract with supports only at front and rear. A new bulletin sent out by Riley Stoker Corp., Worcester, Mass., illustrates these features.

Ramsey-Pulvis Clutch

AUTOMATIC starting clutch designed to permit the driving motor or other prime mover to come up to speed without load, also to give protection against overload shocks and to eliminate the transmission of working strains has recently been placed on the market by the Ramsey Chain Co., Albany, N. Y.

This device, known as the Ramsey-Pulvis clutch, is based on the Pulvis principle of the transmission of power by centrifugally increasing density of hardened steel shot against driving and driven elements of the clutch. According to the manufacturer, the clutch can be made as part of the driving member of industrial drives such as silent or roller chain, flat belt, multiple V-belt, gear types or as a coupling on direct connected drives.



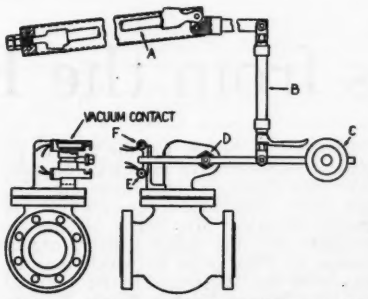
LEFT—ROTOR AND SHELL AT REST; SHOT AT BOTTOM OF SHELL. CENTER—ROTOR AT FULL SPEED; SHELL BEING STARTED. RIGHT—SHELL AND ROTOR AT FULL SPEED IN SYNCHRONISM

Short Center Drive

ROCKWOOD DRIVE for short centers with motor mounted on rocker arms has been redesigned with the base for the motor adjustable lengthwise on the arms to give exact adjustment of belt tension to load requirements. Tension is regulated by the weight of the motor swinging about the pivot shaft, hence change of position of the motor relative to that shaft gives close control of belt tension to avoid belt slip or heating of bearings. Any type of motor may now be used.

Valve Signal Device

NORTHERN EQUIPMENT Co., Erie, Pa., announces a new electric signal device for use with the control valve on the Copes feedwater regulator. It gives instant warning of any abnormal condition in the boiler feed supply by signaling by means of a bell or an electric light if the valve should ever reach the wide-open or fully-closed positions. Application of this new unit is shown by the drawing. Should some abnormal condition cause the valve to reach a fully-closed position, the lever striking vacuum contact "E" closes the circuit for the closed signal. Should the fully-open position be reached, the extended end of the lever strikes vacuum contact F and closes the circuit for the open signal. Vacuum contacts are fully protected in a metallic case which is adjustable to any desired position. The signal may be installed on any Copes control valve.

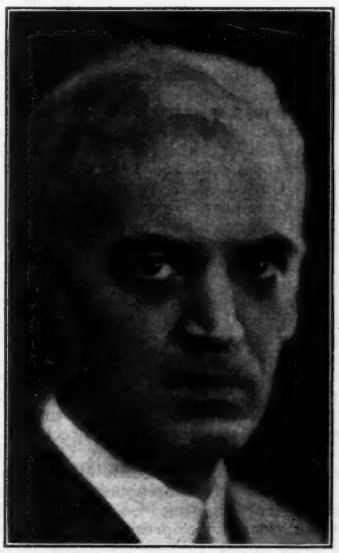


NEW COPES SIGNAL DEVICE TO WARN OPERATOR OF ABNORMAL CONDITIONS IN BOILER

EQUIPMENT for a complete new power plant for the United States Military Academy at West Point, N. Y., has been ordered from the Westinghouse Electric and Manufacturing Co. This equipment includes two 1000-kw., non-condensing turbine generators and a switchboard for the control of these machines and for the distribution of the power generated.

John C. Parker Now Heads Brooklyn Edison

JOHN C. PARKER was elected president of the Brooklyn Edison Co. and Harry L. Snyder was elected president of the New York & Queens Electric Light & Power Co. at a recent meeting of the board of trustees of the Consolidated Gas Co. of New York, to fill vacancies caused by the resignation of Matthew S. Sloan from the presidency of the two companies.



Mr. Parker became vice-president in charge of engineering of the Brooklyn Edison Co. in 1926. He has had wide experience both as a teacher of engineering subjects and as a practicing engineer. He received degrees of Bachelor of Science, Master of Arts and Electrical Engineer from the University of Michigan, and after a year with the General Electric Co. was an instructor in electrical engineering and mathematics at Union College, Schenectady, where he worked under Professor Charles P. Steinmetz.

From teaching he went to Niagara Falls as assistant to the engineer in charge of designing and building the plant of the Ontario Power Co., at that time the world's largest hydroelectric development. Later he became assistant to F. B. H. Payne, vice-president of the Niagara, Lockport & Ontario Power Co. From 1906 to 1915 he was mechanical and electrical engineer of the Rochester Railway and Light Co., Rochester, N. Y.

In 1915 Mr. Parker was ap-

pointed professor in charge of the department of electrical engineering at the University of Michigan, remaining at Ann Arbor until 1922, when he was brought to Brooklyn by Mr. Sloan as electrical engineer of the Brooklyn Edison Co.

Mr. Snyder has been interested in the utility business in Queens since 1899, when he assisted in the merger of two Newtown and two Flushing companies into the New York & Queens Gas and Electric Co. This company was soon reorganized into two companies, operating respectively in the gas and the electric fields. Mr. Snyder was elected secretary and treasurer of both companies, and in 1909 was made president of the New York & Queens Gas Co. He later resigned to devote all his attention to the development of the electric company, of which he became vice president in 1925.

News from the Field

AT THE organization meeting of The United Electric Light and Power Co. on Feb. 9, Frank W. Smith was elected president to succeed Matthew S. Sloan resigned. Mr. Smith is president of of The New York Edison Co. and has been vice-president and general manager of the United Co. Arthur H. Kehoe, electrical engineer, United, and Ralph H. Tapscott, electrical engineer, New York Edison, were elected vice-presidents. John C. Carroll, who has been assistant secretary of United, was appointed treasurer, succeeding George M. Moore, who retires after nearly 40 yr. of service. Assistant treasurers named were Gould A. Stebbins, reappointed, and John E. Scanlan. Melville T. Chandler was reappointed secretary and John H. Aiken assistant secretary and John J. Hooper made a new assistant secretary. New directors of United are Floyd L. Carlisle, Oscar H. Fogg, vice-president Consolidated Gas Co., Eugene H. Rosenquest, president Westchester Lighting Co., and Philip Torchio, senior vice-president of United and New York Edison Companies. At a stockholders' meeting of The New York Edison Co. new directors elected were Charles E. Mitchell, Philip Torchio and George Whitney to replace George F. Baker, deceased, and F. W. Jesser and John D. Ryan, who retired.

HIGHEST-VOLTAGE SUBMARINE CABLE crossing in the world, rated at 115,000 v., is to be installed beneath the Columbia River and the Oregon Slough so that power can be transmitted directly to Portland, Ore., from the new Ariel hydroelectric plant on the Lewis River in Washington. The installation marks the first use of oil-filled cable for a submarine crossing, it is stated. The cable and fittings are being supplied by the General Electric Co. and the installation is to be made for the Northwestern Electric Co. of Portland by the Phoenix Utility Co. Construction of the cable crossing will eliminate several miles of overhead transmission lines, improve transmission efficiency and will make two lines available to afford continuous service.

WORTHINGTON Pump and Machinery Corp., New York City, announces that C. E. Wilson, for past nine years general sales manager, has been appointed vice-president in charge of industrial relations. Mr. Wilson began his career with Worthington in 1899 as a salesman in the Chicago office. In 1905, he was appointed sales manager of that office and later was made assistant general sales manager in charge of all territory from Cleveland to Denver. In 1918 he became assistant general sales manager in charge of foreign business, where he remained until 1923, when he was made general sales manager.

Clarence E. Searle, for the past 17 yr. general representative in charge of sales for Allis-Chalmers Manufacturing Co., has been appointed vice-president in charge of sales. Mr. Searle became associated with the Allis-Chalmers organization in 1908, prior to which time he was with the Western Electric Co. and the Fort Wayne Electric Works (a division of the General Electric Co.). After one year as a sales representative in the Milwaukee office of Allis-Chalmers, he became district manager of that office in 1910. He filled that position until 1915, at which time he was made general representative in charge of sales a position he held until his present appointment.

William H. Baumes, for the past 14 yr. treasurer, has retired at age of 61. Charles N. Barney, for the past 14 yr. secretary and general counsel, has been appointed secretary, treasurer and general counsel. A. L. Prentice, formerly assistant comptroller, is appointed assistant treasurer. Walter Lehman remains, as formerly, assistant treasurer in charge of credits. Frank D. Talmage, formerly member of counsellor's staff, is appointed assistant secretary.

AIR PREHEATER CORP. of Wellsville, N. Y., announces the appointment of Fuel Economy Engineering Co. of St. Paul, Minn., as its representative in the St. Paul territory.

FRICK-REID SUPPLY CORP. has been appointed by Gears and Forgings, Inc., of Cleveland, Ohio, to handle its product in Pittsburgh territory with offices at 117 Sandusky St.

ANNOUNCEMENT is made that C. F. Burgess Laboratories, Inc., of 202 East 44th St., New York City, has taken over the activities of the Burgess Battery Co. in the sale of electronic devices, as well as the acoustimeter line of the Burgess-Parr Co. This move is prompted by the desire of the officials of the various Burgess industries to concentrate the sale of all electronic devices in one organization for greater convenience to all concerned.

DUNBAR ENGINEERING CO., representing the Edward Valve & Manufacturing Co., East Chicago, Ind., has removed its New York City office from 122 East 42nd St. to 21 West St.

M. WILLIAM EHRLICH has returned as chief engineer to Commodore Heaters Corp., New York City, according to a recent announcement. He is a member of the American Society of Heating & Ventilating Engineers, American Society of Mechanical Engineers, also a licensed professional mechanical engineer in the states of New York and New Jersey.

SPEEDY PASSAGE of two municipal utility bills just introduced in the Legislature as a part of Governor Franklin D. Roosevelt's public utility program, was urged Feb. 17 by Delos M. Cosgrove, vice-chairman of the Power Authority of the State of New York, in an address on "Economic Aspects of the St. Lawrence Power Development" at a dinner of the National Association of Cost Accountants at the Hotel Syracuse.

Mr. Cosgrove urged these bills as a practical corollary of the law creating the Power Authority and quoted Section 5 of the Act which directs the Authority to "make provision so that municipalities and other political subdivisions of the State now or hereafter authorized by law to engage in the distribution of electrical current may secure a reasonable share of the power generated at the project * * *."

"In passing the law", he said, "the Legislature in a real sense committed itself to provide Legislation to permit municipalities to go into the utility business if they so desired."

Mr. Cosgrove stressed the securing of low rates for small consumers as the main purpose of the State in undertaking the development of St. Lawrence power and urged the importance of these bills to enable the Power Authority to give the small user of electricity the advantages of potential competition in securing low rates now enjoyed by large industrial purchasers.

"It is impossible", he said "to understand the economic questions involved unless you realize that the State, through the Power Authority, is seeking first of all to supply the urban and rural homes with an abundance of cheap electricity."

"According to the law", he continued, "we are to bargain on behalf of these small consumers and the bargain we make is to be embodied in contracts for the distribution of this power on specified terms."

Mr. Cosgrove suggested that provision for such alternative means of distribution would strengthen the Power Authority's hands in bargaining with the private companies for the distribution of the power and so would render more likely a fair contract. Due to unified control of transmission and distribution facilities throughout the greater part of the State, he said, there is likely to be but a single bidder for the contract.

WORKED POSTPONED sometime ago on the proposed new boiler plant for the Federal Pressed Steel Corp., Milwaukee, Wis. will recommence during the coming spring. Ottomar H. Henschel, 401 Commerce Building, Milwaukee, is consulting engineer and is receiving bids on boilers, stokers, pumps, steam flow meters, turbines, fittings. and other equipment.

For the Engineer's Library

POWER PLANT MANAGEMENT. By Walter N. Polakov; published by the McGraw-Hill Book Co., New York, N. Y.; size 5 by 7½ in.; cloth, 171 pages; price, $2.00.

Job analyses and functions are set forth in detail in this book, which with its detailed directions and sample forms is in reality a handbook covering duties of all employees from the power plant superintendent down to the coal passer This includes a chapter on the steam and power dispatcher in charge of the transmission, distribution and utilization of steam and power throughout the mill or plant. Repair records, timekeeping, storeroom, power cost accounting and the bonus system are also included. The book is short, concise and practical. It is, in effect, a case study of some of the plants where the author installed his system and should have some suggestions that can be used to advantage by the average industrial plant.

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS' GUIDE for 1932; 876 pages, including manufacturers catalog data section, illustrated; 6 by 9 in., flexible leatherette cover; published by American Society of Heating & Ventilating Engineers, 51 Madison Ave., New York City, price $5.00.

Tenth edition of this extremely valuable and interesting work should be part of the equipment of every engineer who has heating and ventilating problems of any kind, not only in buildings and industrial structures but in connection with a great many industrial processes.

The text section contains 40 chapters on design and installation of heating, ventilating and air conditioning systems. About half of the subject matter is entirely new and every chapter has been rewritten and revised. New material is included on heat transfer through materials and constructions; a new chapter on gravity convectors; revised data on fuels and up-to-date information on oil burners, gas heating appliances and heating with electricity; air conditioning for industrial processes is given a separate chapter and the discussions of industrial unit heaters, unit ventilators and unit air conditioners and coolers contain new data. The new chapter on smoke, dust and cinder abatement should prove of interest.

The catalog data section has been coordinated with the text and contains supplementary information on specific materials, equipment and accessories available for the services discussed in the text.

MECHANISM OF COMBUSTION OF SOLID FUELS is the title of Bulletin 49, 21 pages, $0.25, just published by the Carnegie Institute of Technology, Pittsburgh, Pa. A new approach has been made in a fundamental study of the compopsition of solid fuel and the effect of particle size, air velocity, temperature and humidity on the rate of burning of carbon particles investigated under carefully controlled conditions. Another publication which adds greatly to the knowledge of combustion is Bulletin 50, 79 pages, price $1.00. This bulletin is in two parts, Part I, discussing the relative ignitability and relative ease of propagation of flames of powdered coal and semi-coke in air; Part II, the rate of burning of individual particles of solid fuels. Both parts are interesting, dealing as they do with the effect of temperature, particle size and material in combustion. Microphotographs and photographs of the burning tracks of different particles show variations in combustion of individual particles effectively.

FLUID METERS, Part II. Published by the American Society of Mechanical Engineers, 29 W. 39th St., New York, N. Y.; 8 by 10½ in., paper, 61 pages; price, $1.75.

Part II, published as a report of the A. S. M. E. Special Research Committee on Fluid Meters, is a detailed description of meters manufactured by different companies. Contents divided into general classifications of head meters; area meters and thermal meters discusses in detail primary and secondary elements. This is a supplementary volume to Part I, which contains general information regarding design and construction as well as practical instruction and information as may be needed by the user.

MECHANICAL WORLD YEAR BOOK. Published by Emmott & Co., Ltd., 65 King St., Manchester, England; 361 pages, cloth; 4 by 6 in.; price, 1/6 (about $0.30) net.

For 45 yr. this handbook has been a popular source of reference, for engineers working with engines, turbines, boilers, internal combustion engines, shafting, bearings, gearing, hydraulics and related subjects. In this edition several sections have been enlarged, all have been brought up to date and a new one in electric and gas cutting and welding added. The new index is arranged under principal subject headings with suitable cross references inserted to increase its usefulness.

SMOKE AND ITS PREVENTION is the title of Circular 24 of the Engineering Experiment Station of the Ohio State University written by H. M. Faust, research engineer for the station and an authority on coal. This circular explains several possible cures for smoke production in commercial and household heating plants and is illustrated with examples of enforcing smoke regulations in large cities and with drawings and photographs showing proper and improper methods of firing furnaces and the results obtained. Copies of Circular 24 may be obtained free of charge by addressing the Engineering Experiment Station, Ohio State University, Columbus, Ohio.

DETAILED DESCRIPTION of the complete Williams line of drop forgings and drop forged tools, including such products as supersocket wrenches, the new and improved Vulcan superior chain pipe tongs and many refinements and improvements in standard products, are discussed in an attractive, 216-page catalog, the twenty-first edition of the company's catalog, just published by J. H. Williams & Co., 75 Spring St., New York City.

TYPE M double-suction, multi-stage pumps for pumping liquids against high pressure with high efficiencies and supplied in a wide range of sizes and capacities are completely described and illustrated in Bulletin 1642B just issued by Allis-Chalmers Mfg. Co., Milwaukee, Wis. These pumps are built for use in mines, as boiler feed pumps in high pressure boiler plants, in oil pipe line service, water supply systems and similar work.

STEAM AND AIR JET FUEL OIL BURNERS designed to operate with live steam, blower air or pressure air, are described in Bulletin No. 16G just issued by Schutte & Koerting Co., Philadelphia, Pa. A wide range high pressure burner is described in detail, also the SK furnace oil burner, cyclone oil burner, ASKO or low pressure type and flat flame oil burner, as well as the SK gas burner.

R-C-W VICTOR-ACME gas pumps, designed for the handling of clean gas on industrial services, boosting the pressure to the plant itself or increasing the gas pressure to various departments, are described and illustrated in bulletin 31-B10 just issued by Roots-Connersville-Wilbraham, Division of International Stacey Corp., Connersville, Ind.

CONTINUOUS OPERATING AIR FILTERS, designed to be self-cleaning during operation, and furnished in various sizes from 22½ to 46 in. in diameter and from 5 to 11 ft. in height, not including hopper, are completely described and illustrated in a recent bulletin No. 500-1 of the Northern Blower Co., West 65th St. and Barberton Ave., Cleveland, Ohio.

SEMET-SOLVAY Koller Type Gas Producer, its principles, design and details of construction are described and illustrated in detail in Bulletin No. 45 just issued by Semet-Solvay Engineering Corp., 40 Rector St., New York City.

ALLEN-SHERMAN-HOFF CO., Philadelphia, Pa., has appointed the Kent Ervin Engineering Co., Builders Exchange Bldg., Minneapolis, Minn., representatives for the sale of its products in Minnesota, North Dakota, South Dakota and northwestern Wisconsin.

BERNITZ S-100 Super Blocks of Carbofrax material, perforated and blank air-cooled type, are completely described and illustrated in a letter-size, 40-page bulletin just issued by Bernitz Furnace Appliance Co., 89 Broad St., Boston, Mass. This Bulletin, B-341, supersedes Bulletin B-34. It shows the construction of the blocks, discusses their physical and thermal characteristics, shows the way they are applied to various types of furnaces, gives data on air flow and air control and much valuable engineering information on furnace construction.

REX ROLLER CHAINS and Sprockets is the subject of a 112-page, letter-size, leatherette-bound book just published by Chain Belt Co., Milwaukee, Wis. This book discusses the characteristics and advantages of roller chains, gives complete details of construction of Rex roller chains, illustrated in color, and presents a great deal of engineering data on selection, design and applications of roller chains, sprocket cutter design, tables of sizes, proportions and the like.

HIGH-TENSION, across-the-line starting switch is described and illustrated in Bulletin 726, just issued by Allen-Bradley Co., Milwaukee, Wis.

POLYPHASE SQUIRREL-CAGE MOTORS are described in detail and typical speed torque and current curves are given in Bulletin 167, just published by Wagner Electric Corp., 6400 Plymouth Ave., St. Louis, Mo.

JOINTITE CORK PRODUCTS are described and illustrated in detail in a recent 20-page bulletin of L. Mundet & Son, Inc., 461 8th Ave., New York City.

Power Plant Construction News

Ark., Clinton—Clinton Ice & Light Co., recently organized by Clarence H. Tingley, Clinton, and associates, is considering construction of an ice-manufacturing and refrigerating plant, with power substation and distributing system, reported to cost over $50,000.

Calif., Felton—Felton Water Co., Felton, is planning installation of pumping machinery and auxiliary equipment, with 10,000-gal. storage tank, in connection with improvements in waterworks. Installation has been ordered by State Railroad Commission.

Calif., San Francisco—California Carbonic Ice Mfg. Co., 200 Bush Street, E. W. Wilson, president, plans installation of electric power equipment in proposed new dry ice manufacturing plant at Illinois and Twenty-third Streets, entire project to cost over $200,000. C. A. Winder is company engineer.

D. C., Washington—Treasury Department, James A. Wetmore, acting supervising architect, Washington, will receive bids until March 7, for boilers, stokers, forced draft and induced draft fans, soot blowers and auxiliary equipment for central heating plant for public buildings. United Engineers & Constructors, Inc., 112 North Broad Street, Philadelphia, Pa., is engineer.

Ga., Atlanta—Lunsford-Wilson Co., 414 Stewart Avenue, S. W., is considering construction of a one-story electric-operated ice-manufacturing plant on Stewart Avenue, reported to cost over $25,000, with equipment.

Ga., Rossville—Peerless Woolen Mills plan installation of electric power equipment in a new addition to plant, entire project to cost about $100,000.

Ill., Springfield—City Council, Springfield, is having a report prepared covering extensions and improvements in municipal electric power plant, including installation of additional equipment. Burns & McDonnell Engineering Co., Interstate Building, Kansas City, Mo., is engineer.

Ind., Hammond—Lever Brothers, 164 Broadway, Cambridge, Mass., will make extensions and improvements in power plant at soap works at Hammond, in connection with an expansion program to cost over $400,000. Stone & Webster Engineering Co., 49 Federal Street, Boston, Mass., is engineer.

Iowa, Remsen—Town Council, Remsen, is perfecting plans for a municipal electric light and power plant, estimated to cost about $70,000, with equipment. Charles A. Trimmer, Madison, S. D., is consulting engineer.

Ky., Enterprise—Tavern Rock Sand Co., 965 Wall Street, Toledo, Ohio, plans installation of electric power equipment in a proposed new glass sand plant near Enterprise. A power house is proposed. Entire project will cost over $225,000.

Me., Farmington—Franklin Farm Products Co. plans installation of electric power equipment in connection with proposed rebuilding of food products packing plant, recently destroyed by fire with loss of about $40,000.

Mass., Boston—Board of Directors, Hospital Department, 818 Harrison Avenue, is considering extensions and improvements in power plant at city hospital to cost over $200,000, including equipment. James H. Ritchie & Associates, 100 Arlington Street, are architects.

Mass., Malden—Malden Products Co., Inc., recently organized, care of Albert E. Mace Co., Inc., 93 Heath Street, Boston, consulting engineers, plans installation of electric power equipment in new meat-packing plant, entire project to cost over $500,000. Company has taken option on former local rubber shoe factory, and will remodel and equip for initial works. Engineers noted are in charge. Edward G. Lowry is president of company.

Mich., Bergland—Bergland Lumber Co., is said to be planning installation of electric power equipment in connection with proposed rebuilding of portion of mill recently destroyed by fire, entire loss reported at $45,000.

Mich., Detroit—American Nut Co., 676 West Grand Boulevard, plans installation of electric power equipment in connection with proposed rebuilding of bolt and nut works, recently destroyed by fire with loss over $100,000.

Miss., Biloxi—Ness Creameries, Inc., Biloxi, Clifton Cox, general manager, plans installation of motors and other electric power equipment in new one and two-story ice cream plant, 50 x 100 ft., at Callavet and West Howard Streets, entire project to cost about $40,000. Hirsch & Watson, Chemical Building, St. Louis, Mo., is architect.

Mo., Shelbina—Producers Cold Storage Co., Shelbina, is said to be planning construction of a cold storage and refrigerating plant, in conjunction with local plant of Missouri Farmers' Association, estimated to cost over $75,000, with equipment.

Neb., Grand Island—City Council, Grand Island, is having plans drawn for an addition to pumping plant for North Side sewage system, to include installation of pumping machinery and auxiliary equipment. Black & Veatch, Mutual Building, Kansas City, Mo., are consulting engineers.

Neb., Norfolk—City Council, Norfolk, is considering installation of a municipal electric light and power plant. Estimates of cost will soon be made. A petition is being circulated calling a special election to approve project.

N. J., Raritan—Edison Cement Co., Orange, N. J., is negotiating for purchase of former plant of Building Materials Corporation, Raritan Township, and plans extensions and improvements for a new cement mill, with installation of steam and electric power equipment. Entire project estimated to cost about $500,000.

N. C., Asheboro—Acme Hosiery Mills, Asheboro, plan installation of motors and other electric power equipment in proposed new addition to mill. Work will soon begin. Expansion will cost about $35,000.

N. C., Edenton—Farmers' Peanut Co., plans installation of electric power equipment in connection with proposed rebuilding of portion of plant recently destroyed by fire, loss estimated over $125,000.

N. D., Wahpeton—Otter Tail Power Co., Fergus Falls, Minn., plans extensions and improvements in power plant at Wahpeton, including installation of a 7000-kw. steam turbine-generator unit and auxiliary equipment. Work will be placed under way in spring.

Ohio, Dayton—Terminal Cold Storage & Ice Co., Baker Street, has filed plans for a three-story addition, 60 x 85 ft., to ice-manufacturing and cold storage plant, estimated to cost over $50,000, with equipment. George B. Bright, 2615 Twelfth Street, Detroit, Mich., is engineer.

Ore., Klamath Falls—Great Northern Railway Co., St. Paul, Minn., plans installation of electric motors and other electric power equipment in proposed new engine house and shops at Klamath Falls, entire project to cost about $100,000. Engineering department is in charge.

Pa., Barnesboro—Barnesboro Lumber Co., Barnesboro, plans installation of electric power equipment in connection with rebuilding of planing mill and lumber plant, recently destroyed by fire with loss over $40,000.

Pa., Philadelphia—Keebler-Weyl Baking Co., 260 North Twenty-second Street, plans installation of power equipment, conveying and other mechanical equipment in new four-story and basement baking plant, entire project to cost about $850,000. Clarence E. Wunder, Architects' Building, is architect.

S. C., Spartanburg—Hygeia Ice & Fuel Co., Spartanburg, is said to be considering early erection of a one-story refrigerating plant on Kennedy Street, estimated to cost over $30,000, with equipment.

Texas, McGregor—Planters' Cotton Oil Co., Dallas, Texas, plans installation of electric power equipment in connection with proposed rebuilding of portion of cotton oil mill at McGregor, recently destroyed by fire with loss over $80,000.

Utah, Sigurd—Jumbo Plaster & Cement Co., Sigurd, plans installation of electric power equipment in connection with proposed rebuilding of portion of mill, recently destroyed by fire with loss reported over $175,000.

W. Va., Rowlesburg—Buffalo Creek Lumber Co., Etam, (R. F. D. from Rowlesburg) plans installation of electric power equipment in connection with proposed rebuilding of lumber and saw mill, recently destroyed by fire with loss reported over $150,000. A boiler house is projected. Mahlon C. Martin, Jr., heads company.